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CONTRIBUTION TO THE LIFE-HISTORY OF RANUNCULUS.[1]

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(WITH PLATES IV–VII)

IN 1896 a group of research students working in the Hull Botanical Laboratory of the University of Chicago began the investigation of a somewhat wide range of spermatophytes. In addition to the individual problems certain representative forms were selected for joint study, among which was Ranunculus. It was felt that a large multiplication of preparations was desirable, in at least a few cases, to discover the possibilities in variation, and this feeling was justified by the result, since very different conclusions could be drawn from different sets of preparations. It is comparatively easy to obtain a definite sequence in the development of structures when the facts are few, but definite sequences seem to disappear as facts multiply.

The species of Ranunculus chiefly studied were *R. septentrionalis*, *R. multifidus*, and *R. abortivus*, and the results obtained were so constant that it would not be profitable to distinguish in every case among the species in the following account. Certain other genera of Ranunculaceæ were examined also, and they contribute to certain conclusions herein set forth.

[1] Contributions from the Hull Botanical Laboratory. VII. The previous contributions will be found in BOT. GAZ. **20**: 205–212. 1895; **23**: 40–43, 147–179, 252–273, 412–452. 1897; **24**: 93–102. 1897.

It is hardly necessary to refer to the history or literature of this subject, as it has been presented frequently. The paper simply presents certain results obtained from Ranunculus, in reference to structures with whose "normal" behavior morphologists are entirely familiar. It was felt that Ranunculus might be of interest from a phylogenetic point of view, as representing one of the so-called "primitive regions" of dicotyledons.

The usual methods of killing, staining, and sectioning were used, and need no special description.

MICROSPORANGIA AND MICROSPORES.

In the young sporangium a plate of hypodermal cells becomes distinctly differentiated by means of their enlarging radial diameter and prominent nuclei (*fig. 1*). There is great confusion in terminology in reference to these cells and those derived from them, and it is in the interest of clear statement to establish homologous parts, so far as possible, and adopt a uniform terminology. In case this is not possible, at least a consistent terminology should be used throughout a single paper or text. Deferring a brief discussion of this matter to the end of the section, I would regard this plate of cells as the archesporium. Each archesporial cell tends to develop a radial row, and this arrangement remains more or less distinct in spite of certain inequalities of development in neighboring cells. Tracing the development of a single archesporial cell, the sequence of events is very similar to that commonly found in connection with the archesporial cell of the macrosporangium. A periclinal division results in two cells radially placed (*fig. 1*), the outer of which is a primary wall cell and the inner a primary sporogenous cell. From this point, the sequence is variable. Both cells may divide by periclinal walls, or the primary sporogenous cell may divide only in the formation of mother cells. In the former case, the outer cell formed by the periclinal division of the sporogenous cell contributes to the formation of the tapetum. In the latter case the innermost cell derived from the two or three periclinal divisions of the primary wall cell contributes to the tapetum (*figs. 2, 3*).

It would appear that in Ranunculus the cells of the peripheral region of the tapetum may be variable in origin. Of course the tapetal cells on the axial side of the sporogenous tissue cannot in any event be derived from the primary wall cells. The tapetum, therefore, is essentially a morphological composite, and is significant only in its physiological relation to the sporogenous cells. In its peripheral region in Ranunculus it may be derived from the primary wall cell, as in the eusporangiate Filicineæ; or from the primary sporogenous cell, as in the leptosporangiate Filicineæ. In its axial region it may be derived from the adjacent tissue, or cut off from the sporogenous tissue. In some cases it seemed as though the whole of the tapetum were cut off from the periphery of the sporogenous tissue (*fig. 4*), and in other cases (*fig. 5*) its partial derivation at least from primary wall cells seemed equally clear. In the case of an archesporium consisting of a single longitudinal row of cells, as in Cnicus, it was observed that all the cells of the tapetum, with the possible exception of a single peripheral one, were derived from the adjacent tissue. While there may be uniformity in the origin of the tapetum in some cases, enough was seen of the history of the individual archesporial cells to indicate that the cell of the radial row contributing to the tapetum might be sister to the contiguous sporogenous cell, or to a cell derived from the primary wall cell. In any event, the main fact seems to be that each archesporial cell develops a radial row with a varying number of cells; that the innermost cell of this row is sporogenous; that the outer ones are sterile; and that between the two a special nutritive layer is developed (the tapetum) whose constituent cells are determined by position rather then by origin. In general there are two layers of cells in the wall of the sporangium between the endothecium and the tapetum (*fig. 6*), but the number may vary between one and three in the same wall. The cells of the tapetum are occasionally binucleate (*fig. 4*), but not mostly so, as in many other microsporangia examined. In *Hepatica acutiloba* tapetal cells were observed containing from six to thirteen nuclei.

The primary sporogenous cells do not divide extensively, each cell dividing once or twice, so that the mother cells are only two or three times as numerous as the primary sporogenous cells (*fig. 6*). Disorganization of the tapetum and wall layers begins early, so that the mother cells soon become quite free in the loculus (*figs. 4, 6*).

In the development of microspores the usual sequence of events was observed, an ordinary series being shown in *figs. 7–10*. The four spores may be arranged in the usual tetrahedral fashion (*fig. 11*), or may lie in the same plane (*fig. 12*). In both divisions of the mother cell numerous free nucleoli were observed in the cytoplasm (*figs. 12, 13*), and in some cases the bodies were noted which have been regarded as centrosomes (*fig. 14*). In the mature spore the exospore develops fifteen to thirty thin spots for tube extrusion (*fig. 15*).

In the germination of the spore but a single nuclear division was observed in the spore itself, the tube and generative nuclei being approximately of equal size and form (*figs. 16, 17*). In the figures cited it will be noted that the organization of the two into distinct cells has not been accomplished. In Caltha the same division was observed, and upon the complete organization of the generative cell it assumed the usual lenticular form. This form may involve the nucleus itself, or it may be due entirely to the aggregation of the cytoplasm in polar position, the whole distinctly invested by a "Hautschicht."

The term archesporium must either be restricted so as to apply only to those cells which produce mother cells or their equivalents, or it must be extended so as to include those differentiated cells which produce wall cells, tapetum, and sporogenous cells. It is in the latter sense that the term has been used above. This has seemed the more desirable use of the term, as it is far more definite and easy of application. Such a cell is distinctly differentiated, but its progeny may vary considerably, and in the case of Ranunculus the restricted use of archesporium might or might not involve the tapetum.

In the first division of an archesporial cell, in its larger

application, the exterior cell has been called the "primary wall cell," as its derivatives enter into the formation of the wall; rather than the "primary tapetal cell," as its derivatives may or may not contribute to the tapetum. The interior cell resulting from the first division of an archesporial cell is well called a "primary sporogenous cell," as the sporogenous tissue is derived from it, and often nothing else is.

This very customary use of the term archesporium in connection with the microsporangia of spermatophytes, when logically applied to the macrosporangia of spermatophytes and the sporangia of other groups, leads sometimes to a terminology not at all customary. In the case of the macrosporangia of spermatophytes the term archesporium is applied in the same broad sense to the first distinctly differentiated cell. In this cell a periclinal division may or may not take place. If it does occur, as is usual, the exterior sterile cell has been called a tapetal cell, whether it functions as a tapetum or not, and whether it divides further or not. It seems evident that we have here the homologue of the primary wall cell of the microsporangia, which may form several layers, to call all of which a tapetum seems very questionable. In this case it is a question whether the problematical so-called "potential macrospores" do not function as tapetal cells, in which case the "fertile macrospore" may be regarded as the only real sporogenous cell. In view of the uncertain nature of these structures, however, no such terminology is adopted, and the current view that they are spore mother cells is retained.

In such sporangia as those of the eusporangiate Filicineæ, however, a similar application of the term archesporium changes its usual application. The distinctly differentiated superficial cell becomes in this case the archesporium, and the usual periclinal division separates the exterior primary wall cell from the interior primary sporogenous cell (not archesporium).

In the case of such extremely modified sporangia as those of the leptosporangiates, the archesporial cell functions as an apical cell in the development of the stalk, but the usual peri-

clinal division finally separates an exterior primary wall cell from an interior primary sporogenous cell. In this latter case the tapetal layer is evidently cut off from the sporogenous cell, but we have seen that this may occur in other groups as well.

Such an application of the term archesporium has the merit of uniformity and of fairly homologizing its derivatives. It has seemed to me that the term tapetum should disappear as a morphological term, inasmuch as it is a physiological layer between the sporogenous cells within and the sterile cells without, and of variable origin, derived from the wall cells, or from the sporogenous cells, or from the cells of the adjacent tissue.

MACROSPORANGIA AND MACROSPORES.

In the case of *R. septentrionalis* a single hypodermal cell frequently represents the whole of the archesporium (*figs. 18–22*), soon becoming very much larger than the contiguous cells, and with a very conspicuous nucleus. Frequently an axial row of cells beneath this archesporial cell, with prominent nuclei, gives the impression of a row of mother cells (*figs. 19, 21*), but the subsequent history of the larger hypodermal cell proves the contrary. In most cases the epidermal cells capping the single archesporial cell divide once by a periclinal division (*figs. 20, 23*), or occasionally twice, making three layers of cells, but this represents all the development of tissue above the sporogenous cells. In this case no primary wall cell (tapetum) is derived from the archesporium.

In many cases, however, instead of a single archesporial cell, a group of cells forms the archesporium. Regarding only those cells which show by their increased size, prominent nuclei, and reaction, that they are of undoubted archesporial nature, numbers varying from two to thirteen were observed (*figs. 24–26*). In *fig. 26* an archesporium of eight cells is shown. In many cases it was hard to define the archesporium exactly, as cells contiguous to those of undoubted archesporial nature, by virtue of their size and general appearance, certainly suggested archesporial character. The evidence is clear that the single arche-

sporial cell of Ranunculus is but the remnant of an archesporial mass of cells, which still appears in various stages of sterilization. In some cases two or three cells of a several-celled archesporium were observed to develop to mature size, but usually not more than one was observed to divide. In certain preparations, however, development of several of the archesporial cells was observed to have proceeded further (*fig. 27*), some developing to the "two-celled" and "four-celled" condition of the embryo sac. In the case of *R. septentrionalis*, on account of imperfect material, only a single stage of development was noted, but as a complete series was obtained from *R. multifidus*, it seems probable that the same division into four mother cells occurs. In no case was a primary wall cell (tapetal cell) cut off, the archesporial cell dividing directly into mother cells.

In *R. multifidus* the sequence of events from archesporium to macrospore was obtained in detail. Indication of an occasional two or three-celled archesporium was also observed (*fig. 28*). The series of changes from the archesporial cell to the axial row of four mother cells is represented in *figs. 29–32*, and in every case observed the lowest cell of the series developed the macrospore.

In *R. abortivus* the same stages were observed. *Fig. 33* represents a notably well-developed archesporium of two cells, while *figs. 34* and *35* indicate the same steps in the development of the macrospore as those observed in *R. multifidus*. In the last two figures the condition of the integuments indicates the stage of the ovule in which the sporogenous development occurs.

In its earliest condition, after distinct differentiation, the macrospore of *R. septentrionalis* is almost globular (*fig. 36*), with prominent nucleus and nucleolus. Soon it begins to elongate in the direction of the long axis of the nucellus, with enlargement of the nucleus and characteristic ante-division nuclear changes (*fig. 37*). In some cases the macrospore becomes so much elongated as to be cylindrical. The series of nuclear divisions which occur in the macrospore is indicated in *figs.*

38–42, in which may be noted also the constant development of a large vacuole separating the micropylar and antipodal nuclei. The preparations of *R. multifidus* were much more favorable for a study of the mature condition of the embryo sac than those of *R. septentrionalis*. The series shown in *figs. 43–47* may be taken as fairly representative of the mature sac in *R. multifidus*. The strong development of the antipodal cells is a notable feature, distinct walls being developed, the cells enlarging in size and giving evidence of great activity until late in the endosperm formation. The formation of the very large definitive nucleus is plainly shown, and its placing near the oosphere. The general insignificance of the nuclei of the egg apparatus as compared with the others, and their relatively late organization into cells, is at once remarked, synergid nuclei being especially small. In *figs. 43–46* the fact that the synergids are sister cells is evident, and the shifting position of the micropylar nuclei can be traced.

The prominence and activity of the antipodal cells is more marked in certain other ranunculaceous plants than in Ranunculus itself. *Thalictrum purpurascens* and *Hepatica acutiloba* (*fig. 48*), can be taken as illustrations. Associated with the growth of these cells is the usual abundant nuclear division, which, although in every case apparently mitotic, is more or less irregular, as indicated in *figs. 49, 50*, both of which represent the antipodal cells of Hepatica.

It has long since become evident that the most variable region of the embryo sac in dicotyls, preceding fertilization, is the antipodal region. The old formula of three dwindling and evanescent cells, with or without walls, is far from adequate. Such a statement seems to be more true of monocotyls than of dicotyls. In the latter I am able to distinguish at least four distinct types of antipodal development, with the vast majority of forms yet to be investigated. These types merge into one another, but are distinct enough in their extreme expression.

1. A group of evanescent cells, usually three in number. These cells seem to take no part in the activities of the sac, and often disappear so quickly as to give rise to the impression, in

some cases, that no antipodals are formed. In fact, the claim of no antipodals should suggest the probability that the observer is dealing with the evanescent type. So far as researches have gone, this type is characteristic of the Amentiferæ and their allies, is found in Acer, etc.

2. Three large antipodal cells, increasing in size with the sac, sometimes extending almost half through its long diameter, apparently very active, and not disorganizing until after the embryo has begun to develop. This growth of the antipodals is usually associated with extensive division of the nuclei, mostly mitotic in our observations, but undoubtedly sometimes direct. This type is quite characteristic of the Ranunculaceæ and their allies.

3. Usually three comparatively permanent cells, not notable in size or activity, and usually associated with a sac decidedly narrowed at the antipodal end. This type is rather common among the Sympetalæ.

4. An indefinite number of cells, forming a relatively permanent and very prominent tissue, often continuing its growth downwards and breaking through the bottom of the sac. In this somewhat extensive growth the lowest cell is apt to become very large and vesicular, and multinucleate. This type is associated with a narrow, elongated sac, and is quite characteristic of certain sections of the Compositæ, notably the Asteroideæ.

FERTILIZATION.

The phenomena of fertilization are the usual ones, but certain features seem worthy of mention. The pollen tube, after its entrance into the embryo sac, increases rapidly in diameter, in some cases forming a pouch-like tip remarkably large as compared with the caliber of the tube behind (*fig. 51*). The tube passes between one of the synergids and the wall of the sac, and the terminal pouch develops a convex and a concave side, so that the apex of the tube is directed towards the nucleus of the oosphere (*figs. 51, 52*). The tip of the tube apparently breaks down, as in all species we have investigated; at least it lacks

sharp definition and presents a frayed appearance. The distance between the two nuclei at the time of the discharge of the male cell is quite variable. In *fig. 52* it will be noted that the male cell has been discharged at some distance from the nucleus of the oosphere, and that the nourishing synergid gives no special indication of disorganization, unless it be found in the disappearance of the nucleolus. The nourishment of the male nucleus, however, during its movement towards the female nucleus, and increase in size, results in synergid disorganization. In *fig. 51* the two gamete nuclei are shown in a fusion stage, but it will be noted that the second male cell has also been discharged in a very disorganized condition. *Fig. 53* shows an undischarged pollen tube.

ENDOSPERM.

The definitive nucleus is remarkably large, and rests either near the oosphere or becomes somewhat centrally placed in the sac (*figs. 46, 47, 52*). Free nuclear division, with more or less cytoplasmic organization, proceeds with great rapidity (*fig. 54*). In the figure just cited the oospore has not yet divided, while six free endosperm cells are represented. The prominence of the antipodal group is also noticeable, as well as its somewhat lateral position, due to the beginning of the remarkably one-sided development of the sac. That this formation of free endosperm cells proceeds not only with rapidity, but in a remarkably simultaneous fashion, is indicated by the great numbers of spindles in practically the same stage (*fig. 55*). The figure cited represents but a portion of the embryo sac. A more detailed view of an endosperm spindle is shown in *fig. 56*, in which the radiations about the poles are remarkably clear. During the formation of free endosperm cells the sac enlarges rapidly, both laterally and downward, but chiefly upon one side, so that eventually the still prominent and active antipodals are on one side of the lower broad end of the sac, and are frequently thrust out conspicuously into the cavity on a stalk-like projection, which represents the original center of the bottom of the sac (*fig. 57*). This is

decidedly different from the method of sac development in the monocotyls we have studied, in which the sac enlarges above the base, leaving the dwindling antipodals at the bottom of a pit-like depression, which sometimes is thrust to one side of the center. The one-sided development of the sac is determined by the fact that it is obstructed on one side by the conspicuous fibrovascular bundle, while the other side and bottom are directed towards the free cavity of the ovary.

At this stage of development the endosperm nuclei, formerly distributed through the cavity of the sac, have assumed the parietal position, forming a complete lining layer, interrupted only by the embryo and the antipodal stalk. It will be noted in the figure last cited that the embryo has completed only the first division.

The most interesting phenomenon in connection with the formation of endosperm, however, was the occasional evidence of its formation before the fusion of gametes, and even before the entrance of the pollen tube into the cavity of the sac. In *fig. 58* a preparation is shown in which the large egg is lying in the very apex of the sac, the two synergids being apparent in an adjacent section, and yet free endosperm nuclei are distributed through the sac, and are even assuming the parietal position.

It does not follow, however, that the endosperm begins to form without any stimulus from the pollen tube. The presence of the tube in the style is known to exert a strong influence upon the adjacent tissues, which may well be felt in the embryo sac. The beginning of endosperm formation, therefore, even though observed before the entrance of the pollen tube into the embryo sac, may none the less be definitely related to the phenomena of fertilization, of which the entrance of the tube and the fusion of the gametes are only a part.

The parietal placing of endosperm cells is a phenomenon of orientation which deserves consideration. That the curving of the tip of the pollen tube towards the nucleus of the oosphere and the movement of the male nucleus towards it are phenomena that depend upon chemotropism seems to be a satisfactory

explanation; but the parietal placing of free endosperm cells is not to be explained in any such way. The phenomenon may be likened to that observed in connection with certain animals and animal cells, which seek a solid support that seems to be essential to their further activity. In the case of endosperm cells the parietal position is usually antecedent to the formation of cell walls.

EMBRYO.

There seems to be a general rule in the early divisions of the embryo, subject however to numerous exceptions, the causes of which are doubtless accessible. The oospore usually elongates considerably, with the nucleus at the distal extremity, and the vacuole conspicuous. The sequence of events in both *R. septentrionalis* and *R. multifidus* is so nearly identical that they will be considered together. As is to be expected, the first division is transverse, the terminal cell being smaller (often much smaller) than the other (*figs. 59–61*). In the last figure cited a sudden bending of the young embryo from the persistent synergid may be noted. The next division is also transverse, but it may occur either in the basal or apical cell (*figs. 62–65*). In the first figure cited the presence of a spindle in the basal cell definitely establishes the origin of the second wall in this case. There is also evidence that the second division may occur in the apical cell (*fig. 64*). In any event, a row of three cells seems invariable. Usually the third division is also transverse, apparently occurring in any one of the three cells previously formed, forming a row of four cells (*figs. 66–67*). This row of three or four cells uniformly precedes any longitudinal division. It would seem clear in this case that the suspensor may not arise wholly from the basal cell of the first division; and that the apical cell of the first division may contribute to the formation of the suspensor as well as to that of the embryo. After the row of three or four cells has been formed, the first longitudinal division occurs, and, so far as our preparations show, always in the apical cell (*figs. 68–70*). The persistence of the synergid unused in

the processes of fertilization is also evident. After the apical cell has divided longitudinally, similar divisions may occur in all other cells of the primary row or in some of them (*figs. 71–72*). This variation in the formation of longitudinal divisions in the suspensor region is apparent even in much older embryos. Occasionally a late transverse division in the basal cell was observed (*fig. 73*).

The most advanced stages of the embryo studied show considerable development of the suspensor, and the complete cutting off of a peripheral region of the embryo by periclinal walls, but no differentiation of the organs of the embryo.

The students who contributed preparations and drawings to this paper are O. W. Caldwell, T. C. Frye, Florence M. Lyon, W. D. Merrell, Mabel L. Merriman, J. H. Schaffner, and W. R. Smith. Their initials in connection with the drawings indicate the individual contributions. The laboratory work and the preparation of the plates were cared for by Dr. C. J. Chamberlain.

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EXPLANATION OF PLATES IV–VII.

The drawings have been reduced to three-eighths of their original size, and were made with an Abbé camera. Unless otherwise indicated the ocular combination was Reichert ocular 4 and Bausch and Lomb $\frac{1}{12}$ oil immersion

PLATE IV.

FIG. 1. Microsporangium of *R. septentrionalis*, showing row of hypodermal archesporial cells, in one of which is a spindle of the first periclinal division.

FIG. 2. Microsporangium of *R. multifidus*, in which the sporogenous cells are distinct, and the tapetal layer appears to have been developed from the wall. Leitz oc. 4, obj. 7*a*.

FIG. 3. The same, with anther wall further developed. Same combination.

FIG. 4. Microsporangium of *R. septentrionalis*, in which the prominent tapetal layer seems to be more related to the sporogenous cells.

FIG. 5. Microsporangium of *R. multifidus*, showing a definite relation of tapetal cells to the wall layers, and a differentiation of the endothecium. Leitz oc. 4, obj. 7*a*.

FIG. 6. Microsporangium of *R. septentrionalis*.

FIGS. 7–11. Development of microspore tetrad in *R. septentrionalis*.

FIG. 12. Second nuclear division in pollen mother cell, occurring in same plane, and showing free nucleoli and kinoplasmic threads. Zeiss oc. 18, obj. 2^{mm}.

FIG. 13. First nuclear division in pollen mother cell of *R. multifidus*, showing free nucleoli and polar radiations. Leitz oc. 4, obj. $\frac{1}{12}$.

FIG. 14. First nuclear division in pollen mother cell of *R. multifidus*, showing "centrospheres."

FIG. 15. Microspores of *R. septentrionalis*, showing thin areas in the exospore. Leitz oc. 4, obj. 7*a*.

FIGS. 16, 17. Mature microspores of *R. septentrionalis*, showing the two nuclei.

FIGS. 18–20. Macrosporangium of *R. septentrionalis*, with single archesporial cell; in *fig. 20* a periclinal division is represented in the overlying epidermal cell.

FIG. 21. The same, showing subjacent row of cells in the sporangium sometimes mistaken for a row of mother cells.

FIG. 22. The same, showing enlargement and first nuclear division.

FIG. 23. The same, showing the first division completed.

FIGS. 24, 25. Archesporium of *R. septentrionalis*, composed of more than one cell.

PLATE V.

FIG. 26. Macrosporangium of *R. septentrionalis*, with eight-celled archesporium.

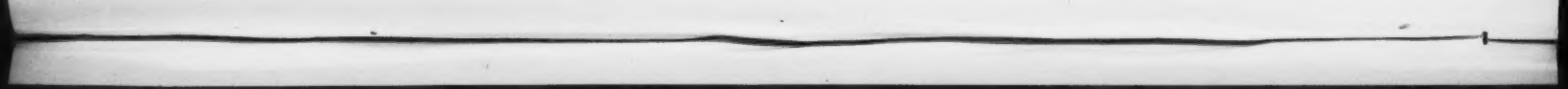
FIG. 27. The same, with three archesporial cells in an advanced stage of development, the two to the right in the "two-celled" and "four-celled" stages of the embryo sac. Zeiss oc. 4, obj. 2^{mm}.

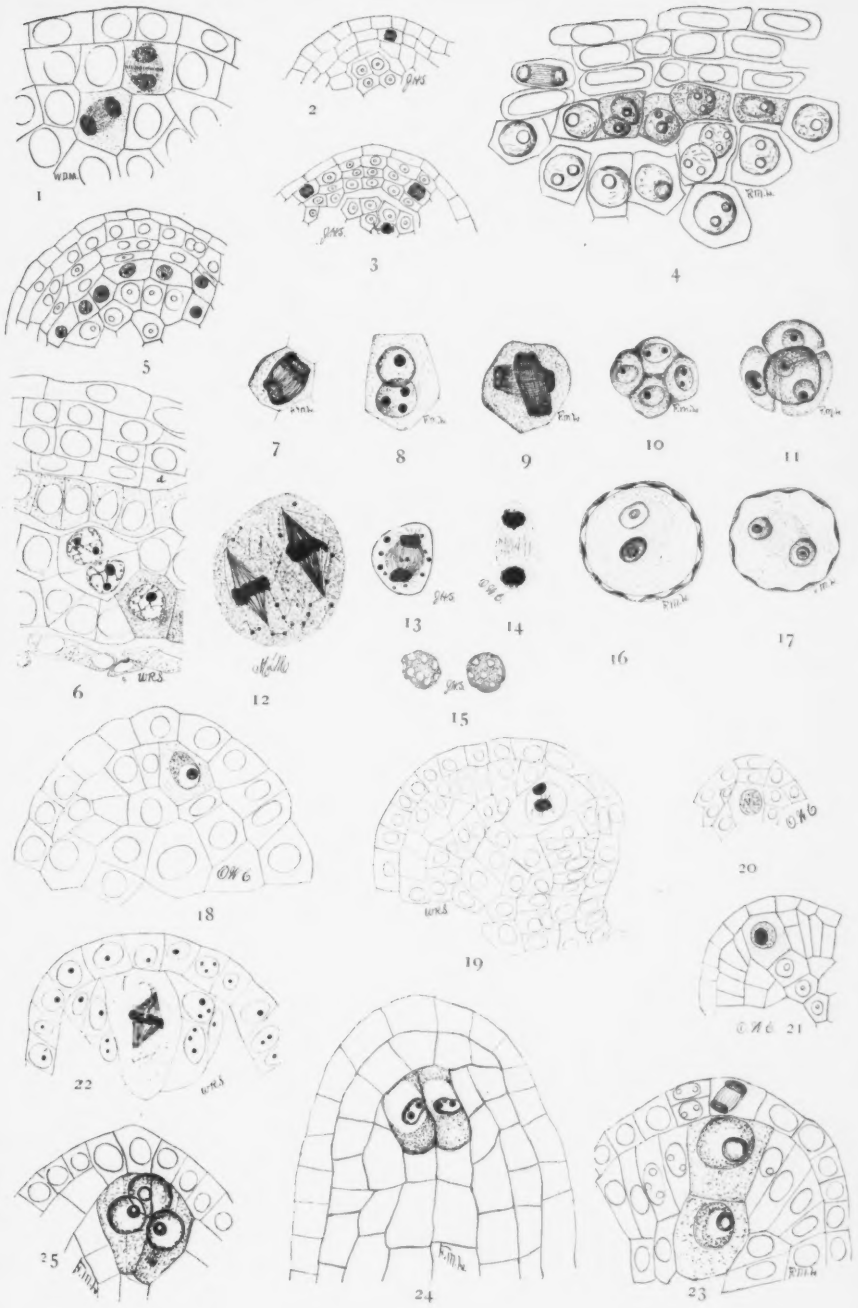
FIG. 28. Macrosporangium of *R. multifidus*, with the remains of a second archesporial cell.

FIGS. 29–31. The same, showing successive stages in the development of the row of four mother cells.

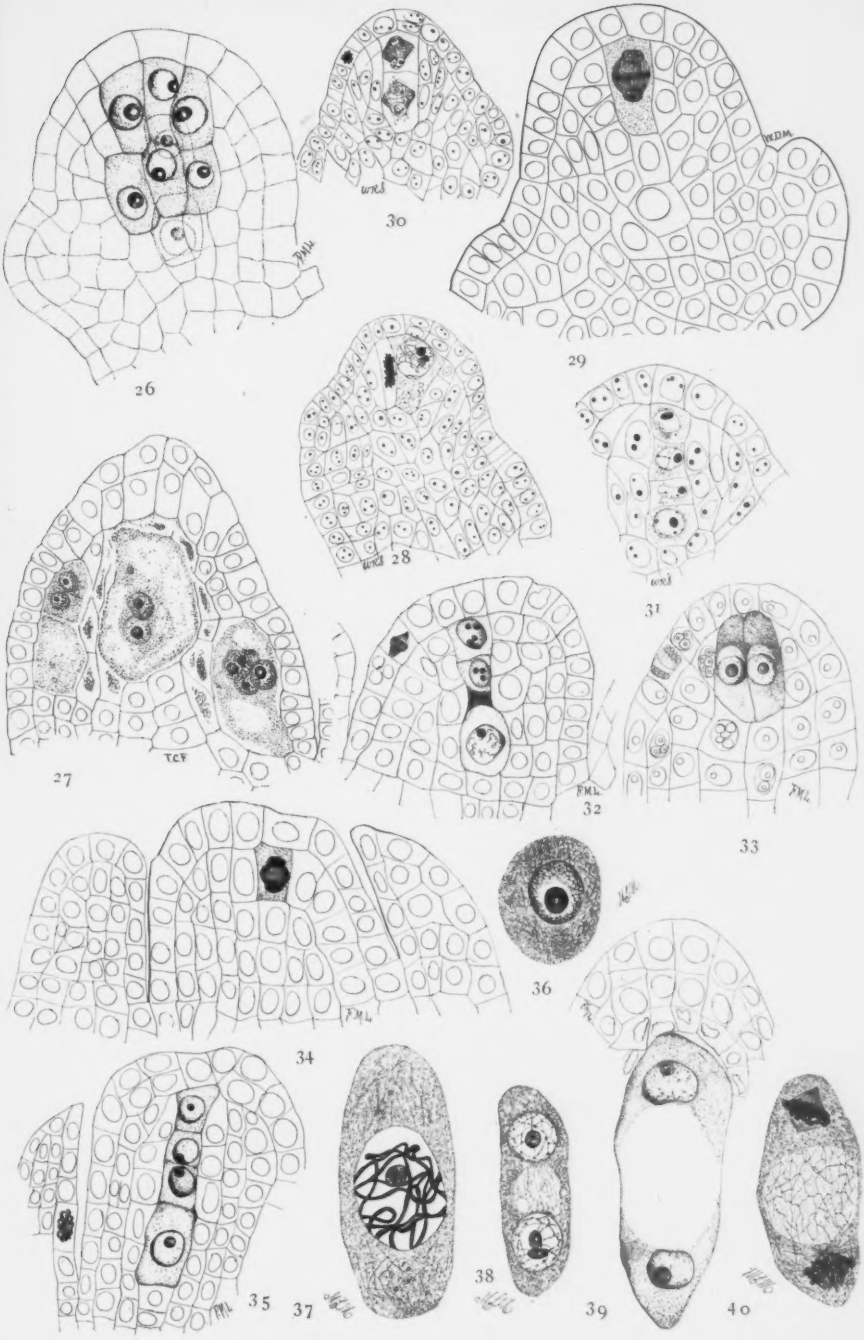
FIG. 32. The same, showing the beginning of the enlargement of the fertile mother cell, and the destruction of the adjacent cell.

FIG. 33. Macrosporangium of *R. abortivus*, showing a two-celled archesporium.





COULTER on RANUNCULUS.



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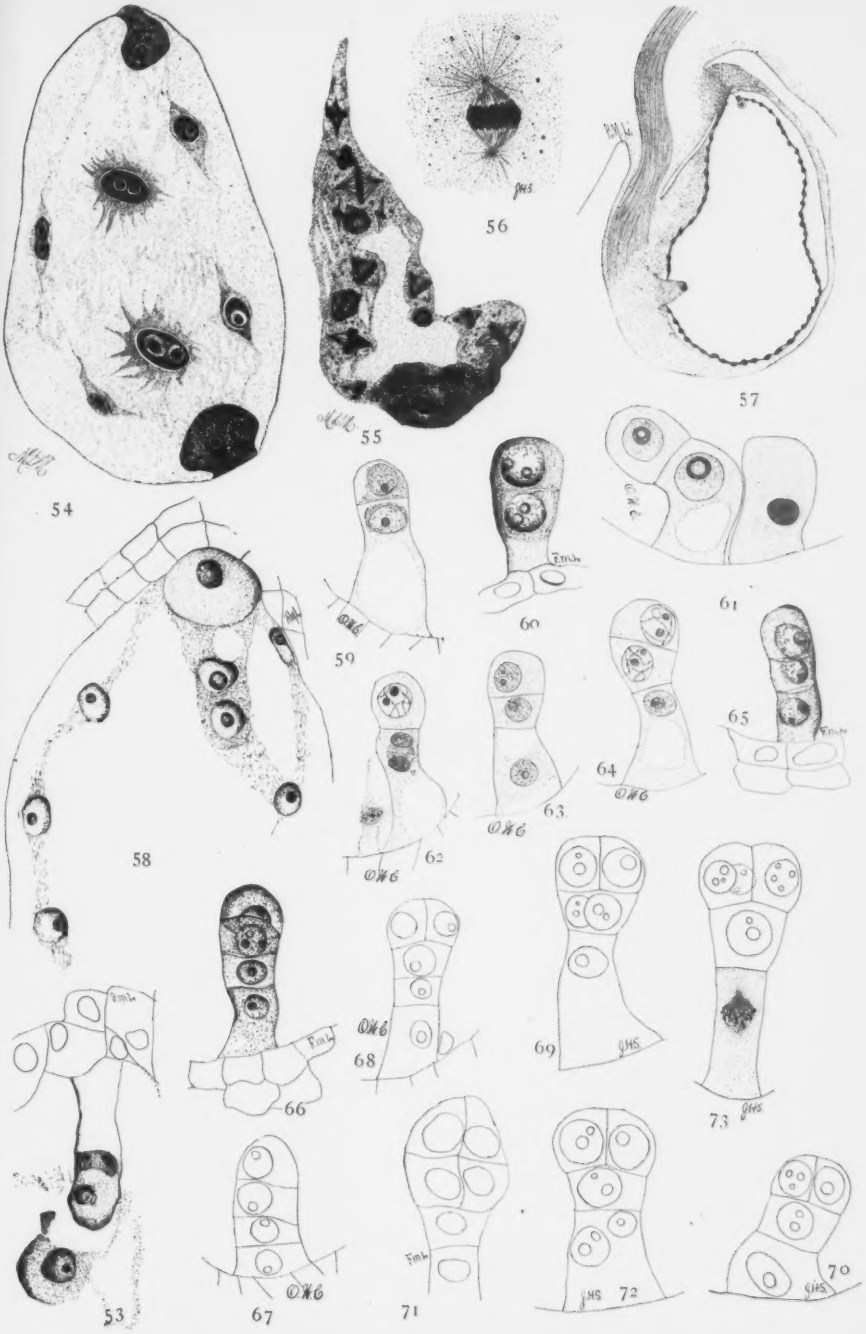


COULTER on RANUNCULUS.

FIGS. 34, 35. The same, showing first and last stages in the development of the mother-cell row.

FIGS. 36–40. Stages in the nuclear divisions of the embryo sac of *R. septentrionalis* (except *fig. 39*, which is from *R. multifidus*). In every case the micropylar end is the upper one. In *fig. 40* the antipodal spindle shows polar radiations at one end and a multipolar character at the other. Zeiss oc. 18, obj. 2^{mm} (except *fig. 39*).

PLATE VI.

FIG. 41. Embryo sac of *R. septentrionalis*, showing completion of the second nuclear division. Zeiss oc. 6, obj. 2^{mm}.

FIG. 42. The same, showing spindle of the third division. Zeiss oc. 4, obj. 2^{mm}.

FIGS. 43–46. A series from the embryo sac of *R. multifidus*, showing fusion of polar nuclei and the organization of the egg apparatus. Zeiss oc. 6, obj. 2^{mm}.

FIG. 47. Mature embryo sac of *R. multifidus*.

FIG. 48. Mature embryo sac of *Hepatica acutiloba*.

FIG. 49. Antipodal cells of *H. acutiloba*, showing extensive unequal mitotic divisions. Zeiss oc. 6, obj. 2^{mm}.

FIG. 50. The same, Zeiss oc. 8, obj. 2^{mm}.

FIG. 51. Embryo sac of *R. septentrionalis*, showing pollen tube, fusion of sex nuclei, and the disorganized but discharged second male cell.

FIG. 52. Embryo sac of *R. multifidus*, showing discharge of male cell at some distance from the oosphere nucleus, also the very large definitive nucleus.

FIG. 53. Embryo sac of *R. septentrionalis*, showing undischarged pollen tube approaching the oosphere nucleus.

PLATE VII.

FIG. 54. Embryo sac of *R. multifidus*, with free endosperm nuclei and an undivided oospore. Zeiss oc. 18, obj. 2^{mm}.

FIG. 55. The same, showing simultaneous formation of endosperm spindles. Zeiss oc. 6, obj. 2^{mm}.

FIG. 56. An endosperm spindle of *R. multifidus*, showing very clear polar radiations. Reichert oc. 12, Leitz obj. $\frac{1}{12}$.

FIG. 57. Embryo sac of *R. septentrionalis*, showing the one-sided enlargement of the sac, the lateral position of the antipodals, the parietal layer of endosperm nuclei, and a two-celled embryo.

FIG. 58. Embryo sac of *R. multifidus*, with egg and free endosperm nuclei.

FIG. 59. Two-celled embryo of *R. multifidus*.

FIG. 60. The same of *R. septentrionalis*.

FIGS. 61–64. Two to three-celled embryos of *R. septentrionalis*.

FIGS. 65. Three-celled embryo of *R. septentrionalis*.

FIG. 66. Four-celled embryo of the same.

FIG. 67. Four-celled embryo of *R. multifidus*.

FIGS. 68–72. Various stages in young embryos of *R. multifidus* (*fig. 71* is from *R. septentrionalis*), involving the first longitudinal division.

FIG. 73. Young embryo of *R. multifidus*, showing a late transverse division of the basal cell.

OBSERVATIONS ON SOME WEST AMERICAN THERMAL ALGÆ.

JOSEPHINE E. TILDEN.

(WITH PLATES VIII–X)

IT is the purpose of this paper to present an annotated list, with drawings, of thermal algæ, based on collections made in several western localities during the past two years.

Collection no. 1 was made by the writer in Yellowstone National Park during June and July of 1896. Specimens were preserved in formalin and a quantity of each kind was also dried. The natural color of the growths *in situ* was compared with the plates in Saccardo's *Chromotaxia*, ed. 2, 1894.

The hot waters of the Park are either calcareous, as at Mammoth Hot Springs, or contain silica in solution, as at Norris, Lower, Middle, and Upper Geyser Basins. Travertine results from the growth of algæ in calcareous waters, and siliceous sinter in siliceous waters.

Collection no. 2 was made by the writer from warm springs at Salt Lake City, Utah, in July 1897.

Collection no. 3 was made by the writer from the Natural Sulphur Spring at Banff, Alberta, during the month of August 1897. The warm springs of Banff are used for bathing purposes. They are situated on high ground and most of the overflow is carried away by means of ditches, several feet deep, which lead down the steep hillside. Here the water accumulates on a level space and forms a shallow but quite extensive pond or lake. Some of the overflow escapes underground for a short distance and appearing again halfway down the hill spreads out in terraces and finally joins the stagnant water below. These sheets of water have naturally lost much of their heat, but they are still tepid and support a luxuriant growth of Chara and other

Chlorophyceæ, numerous species of mosses, equisetum, etc. The water in the ditches is only a few inches in depth, but has a swift current. By the time it has reached the base of the hill it is but slightly warm. The older portions of the "formation" on this hillside are composed of travertine produced by mosses.

Collection no. 4 was made by Mr. Walter Harvey Weed in Yellowstone National Park during 1897, and sent to me for determination. This adds new localities and several new forms to the list.

Collection no. 5 was made by Professor Francis E. Lloyd from hot springs in the region of the Cascade mountains, Oregon.

OEDOGONIUM CRENULATO-COSTATUM Wittr. var. AUREUM Tild. Am. Alg. Cent. II. no. 123. 1896. (*Pl. VIII, figs. 1, 2, 3.*)

Oogonia single or 2–3-seriate, elliptical or oboviform, opening by a pore in upper portion; oosperms nearly filling the oogonia, exospore smooth, endospore crenulate-costate, reticulate, orange-colored (*aurantiacus*); supporting cell similar to the other vegetative cells; filament of male plant slightly smaller than that of female; antheridial cells alternating with vegetative cells, 2–5-celled; terminal cell (sometimes an oogonium) obtuse; vegetative cells 10–13 μ in diameter, 3.5–6 times longer; oogonia 32–37 × 40–50 μ; oosperms 29–30 × 38–39 μ; antheridial cells 10 × 10 μ. In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

The endospore in this plant is crenulate-costate, but with transverse as well as longitudinal costae; the dimensions of the vegetative cell differ a little from those given in the type description; the mature oospores are bright orange-colored, a character not mentioned in the specific description; it occurs in thermal, flowing water, instead of cold stagnant water. In all other respects the variety is similar to the species.

An Oedogonium was also found in the tepid terrace waters at Banff, but as it was not in fruit the description is omitted. For a like reason a species of Zygnema growing with it is not described.

HORMISCIA FLACCIDA (Kg.) Lagerh. var. CALDARIA (Kg.) Hansg. Prodr. 61. 1886–1888 and in Flora 265. 1888. Tilden. Am. Alg. Cent. II. no. 130. 1896. (*Pl. VIII, figs. 4, 5.*)

Stratum dull green, soft, in long strings, dark green in the current, light green scum in the standing water; vegetative cells 5–7.5 μ wide, 0.5–2 times as long as the diameter.

In water from hot spring flowing down a grassy bank. Temperature 23° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 26 Je 1896.

This form seems to agree almost equally well with the above variety and with *H. subtilis* (Kg.) De Toni var. *thermarum* (Wartm.) Rabenh. Like the former, it occurs in soft somewhat lubricous masses. Its measurements correspond exactly, if the cells undergoing division be excepted. A filament made up entirely of mature cells would resemble Kützing's figure in *Tab. Phyc.* **3**: *pl. 32, f. 3.* 1853. On the other hand, its habitat seems to accord better with the latter variety. When compared with Rabenhorst's Algen Sachs. no. 655 (placed here by De Toni) there is found to be no special difference in appearance. The diameter of Rabenhorst's specimen is slightly greater, perhaps, and the length of the cells, while in general 1–1.5 times the diameter, in many cases is twice the diameter. It would then appear that the Yellowstone plant agrees with the description of one species and an authentic specimen of another species as these are offered in De Toni's *Sylloge Algarum.* If forma *crassior* Hansg. of var. *thermarum* be taken into account, there would seem to be no objection to making a single variety of the two, especially as they belong to species so nearly related. In that case, according to the rule of priority, the plant would take the above name.

CONFERVA MAJOR (Kg.) Rabenh, forma **ferruginea**, n. f. (*Pl. VIII, figs. 6, 7, 8.*)

Brownish (*ferrugineus, fulvus*); filaments encrusted with ferric-oxide (Fe_2O_3), sometimes in narrow bands, generally forming extensive coatings; cells 13–20 μ in diameter, twice the diameter in length, after division equaling the diameter.

In acid waters of overflow. Temperature 74° C. "These algæ are in part coated with Fe_2O_3 on the margins of the pools." Echirus Geyser. W. H. W. 1897.

The width of the filament in the form is somewhat narrower than that of the species. The specimen shows well the "letter H" appearance of the ruptured membrane which De Toni makes a generic character.

CONFERVA MAJOR (Kg.) Rabenh. forma **gypsophila,** n. f. (*Pl. VIII, figs. 9, 10, 11.*)

Forming white or yellowish masses; filaments encrusted with crystals of gypsum; cells 10–20 μ in diameter, twice as long as wide, after division equaling in length the diameter; cell contents granular, colorless; cell membrane thick.

Lying near vent of spring. Temperature 66° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

This plant likewise differs from the species in having a narrower filament. Little spiny or lobed masses of gypsum, a centimeter in thickness, are found entwined with the threads.

MICROSPORA AMOENA (Kg.) Rabenh. forma **thermalis,** n. f. (*Pl. VIII, fig. 12.*)

Dark green, stringy; cells cylindrical, 11–14 μ in diameter, before division 2–3 times as long as wide, after division equal to or a little more than the diameter in length; membrane smooth, delicate, firm; cell contents finely granular, bright green; filaments not constricted at septations.

(*a*) Lying in overflow from spring. Temperature 41° C. Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896.

It is difficult to decide whether this plant should be classed as a Conferva or a Microspora, as the structure of the chloroplastids could not be made out. It is placed here provisionally. Its size is not as great as that of the species.

(*b*) A second gathering, slightly different in color, was

vegetative green becoming yellowish. It occurred in soft masses on bottom of a spring. Temperature 38° C. Locality and date same as above.

In the first collection small prickly masses of mineral formation, probably gypsum, also occurred. *Chroococcus varius* was present in great quantity. The second collection contained Protococcus cells.

Microspora Weedii, n. sp. (*Pl. VIII, fig. 13.*)

Cespitose-floccose, dark green in denser parts, pale bluish-green in thinner portions; vegetative cells cylindrical, sometimes a little constricted at the septations, 7–9 μ in diameter, before division 0.5–3 times longer than diameter; membrane homogeneous, hyaline, thin.

(*a*) Bright green. Forms jelly on slope. Temperature 49° C. Growler, Norris Basin, Yellowstone National Park. W. H. W. 1897.

The peculiar bluish-green color is no doubt caused by the action of the formalin upon the plant, but it is worth noting since it has not been observed in other formalin material of the green algæ. The plant probably is nearest to *M. abbreviata* (Rabenh.) Lagerh. but differs from it in being entirely free from the ferruginous color, in having a thin membrane, and in its habitat.

Rhizoclonium hieroglyphicum (Ag.) Kg. var. **atro-brunneum**, n. var. (*Pl. VIII, figs. 14, 15, 16, 17.*)

In long strings, dark brown (*fuligineus*); normal vegetative cells 15–22 μ in diameter, less than once as long to three times longer than wide, very variable in size in the same filament, rarely producing short rhizoids; cell contents (examined when fresh) dark brown, granular.

(*a*) In shallow water, plastered to surface of ground, most luxuriant in slow current. In overflow, through grass, of hot spring on bank above. Temperature 24° C. Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) Dull brown filaments. In overflow channel. Temperature 38° C. Near Constant Geyser, Norris Geyser Basin, Yellowstone National Park. W. H. W. 1897.

Nearly every filament of my specimen contains one or more distorted cells. These are sometimes swollen to several times the size of the normal cells, and in general have a thicker wall. It was first thought that the plant might be identical with or at least related to *Hormiscia ? thermalis* Crouan (in Mazé and Schramm *Algues de la Guadeloupe* ed. 2, p. 42). But since access cannot be had to this specimen and the data furnished in the type description (De Toni *Sylloge Algarum* **1**:171. 1889) is confined to a statement of the color and habitat—"Atro-brunnea. Hab. ad muros lateritios in aquario thermali (36° C) ad 'Dolé' insulae Guadeloupensis (Coll. n. 351. II série)"—it is thought best to place it under the above name.

Mr. Weed's specimen appears to be exactly the same plant. It shows, however, almost no trace of the distortion and no lateral projections could be found.

PROTOCOCCUS BOTRYOIDES (Kg.) Kirchn. forma **caldarius,** n. f. (*Pl. VIII, fig. 18.*)

Aquatic, vegetative or yellowish green; cells globose, 4–6 μ in diameter, for the most part solitary; membrane thin, homogeneous, hyaline; cell contents homogeneous, vegetative green.

(*a*) On bottom of spring. Temperature 38° C. With *Microspora amoena*, forma *thermalis*. Frying Pan Basin, Yellowstone National Park. J. E. T. 7 Jl 1896. Agrees with species with exception of habitat.

CALOTHRIX THERMALIS (Schwabe) Hansg. Beiträge zur Kenntniss der Böhmisch. Thermalalgenflora (Oesterr. Bot. Zeitschrift **34**:279. 1884. (*Pl. IX, figs. 1, 2, 3, 4, 5.*)

Stratum soft, dark seal brown or black; filaments crowded, flexuose, 10–13 μ, rarely 18 μ in diameter, thickened at base; sheath in young plants thick, lamellated, colorless, in older plants wider, brownish; trichome in young plants 5–9 μ in

diameter, bright blue-green, granular, distinctly articulated or rarely with dissepiments not visible, sometimes moniliform, in older plants paler aeruginous, much narrower, with shorter articulations, not plainly visible, with apex tapering to a hair-point; articulations equal in length to diameter, but often, particularly in younger plants, twice the diameter in length; heterocysts 1–2 seriate, basal or intercalary, very variable in size and shape.

(*a*) Overflow of channel of geyser. Temperature 49–54.5° C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*b*) Forming cedar-colored fur on overflow channel of geyser. Old Faithful Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) With other algæ in rivulets. Temperature 49–50° C. Fountain Hotel Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

(*d*) Very common in colder portions of overflows. Varying in color from *umbrinus* to *castaneus* and *fuligineus*. Growing in small islands or forming smooth surfaces. Temperature 34° C. Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

Mr. Weed has frequently mentioned this plant, but under other names. He describes an algal sinter which, "forming in the overflow channels of many of the geysers of the Upper Basin, is finely fibrous, consisting of layers one-sixteenth of an inch to half an inch thick, each stratum resembling a very fine thick white fur. This sinter is formed by the growth of the little algæ, *Calothrix gypsophila* Kg., or the young form, *Mastigonema thermale*, the latter olive-colored."[1] Again, "the proportion of algal sinter forming the deposits about the Geyser Basins is strikingly shown in the following section of the strata forming the wall of Excelsior crater. . . . . In this section 50 per cent. consists of the fibrous sinter formed by

[1] Formation of travertine and siliceous sinter by the vegetation of hot springs. U. S. Geol. Surv. 9th Ann. Rep., 665. 1889.

Mastigonema."[2] He describes a specimen of New Zealand sinter from the hot waters of Rotorua, and notes that "the exact counterpart of this sinter occurs at many localities in the geyser basins of the Yellowstone, notably about the Prismatic Spring and the overflow channels of Old Faithful. It forms over one-half of the section of fifteen feet of sinter exposed in the crater walls of the Excelsior Geyser. This sinter we know to be the result of the growth and incrustation of little algæ, which form a cedar-colored (*Calothrix gypsophila* Kg.), or olive (*Mastigonema thermale*) slippery coating on the surface of the deposit. The analogy is so perfect that there seems but little doubt that the New Zealand sinter is the result of the growth of similar or allied algæ."[3]

The plant *Calothrix gypsophila* (*Dichothrix gypsophila*) is a lime-encrusting form. I have not personally observed it up to this time in material from Yellowstone Park. *Mastigonema thermale*, a synonym of *Calothrix thermalis*, does not characteristically secrete lime. The Yellowstone form has only been found in siliceous waters. It differs slightly from the type description of Bornet and Flahault in that the articulations, instead of being "diametro æqualibus vel usque ad 3-plo brevioribus" are equal to up to three times *longer* than the diameter. It agrees, however, in this character with Hauck and Richter's specimen in *Phyk. univ.* no. 742, which was collected from the Carlsbad springs in 1894 and 1895 by S. Schmula. Therefore the two forms named by Mr. Weed are considered to be the same plant.

The above species has been described from Carlsbad, Germany, by Schwabe, Kützing, and Cohn.

RIVULARIA HAEMATITES (DC.) Ag. Syst. Alg. 26. 1824. (*Pl. IX, figs. 6, 7, 8, 9.*)

Thallus forming a hard calcareous crust, 5^{mm} in thickness; filaments dense, 7.8–11.7μ in diameter; sheath narrow, hyaline, rarely brownish; trichomes 3.9–5.2μ in diameter, with lower

[2] Loc. cit. [3] Loc. cit. 674.

cells one to two times longer than wide, middle cells two to three times longer than wide, and upper cells in general subquadrate, with apex prolonged into a thread; cell contents granular.

Forming a calcareous crust on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

This growth occurs toward the lower end of the ditch where the water is slightly warm and the current very swift. The general appearance and microscopic characters agree very well with authentic specimens in the Minnesota herbarium.

HAPALOSIPHON MAJOR Tild. Am. Alg. Cent. II. no. 167. 1896. (*Pl. IX, figs. 10, 11, 12, 13.*)

Stratum widely expanded, bright aeruginous in color; filaments sheathed, branched, composed of cells sometimes cylindrical, 3–6μ in width, showing no dissepiments, or divided into short somewhat quadrate to very long cells, sometimes globose up to 11μ in diameter; branches single or geminate, sometimes geniculate; heterocysts intercalated, oblong, cask-shaped, about 8μ in width, one to two times as long as wide.

(*a*) Completely coating bed of very swift mountain rivulet, at vent of hot spring. Temperature of spring 61° C. Algal growth begins here and disappears at a distance of fifty-five feet from spring where temperature is 51° C. Most luxuriant growth thirty-five feet from spring at temperature of 54° C. Mountains near Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) In hot spring. Temperature 55° C. Cascade mountains, lat. 45° 20′. Francis E. Lloyd, 1895.

The filaments of *H. major* are nearly twice the diameter of those of *H. laminosus*. An important character of the latter plant is its habit of forming crystals of lime, according to Cohn, who studied the plant at Carlsbad. The Yellowstone species occurred in siliceous waters only, at least it was not discovered at Mammoth Hot Springs, where the waters contain calcium carbonate.

SCHIZOTHRIX CALCICOLA (Ag.) Gomont, Monographie des Oscillariées, Ann. Sci. Nat. (Bot.) VII. **15**: 307. *pl. 8, figs. 1–3.* 1892. Tilden, Am. Alg. Cent. II. no. 180. 1896. Described in BOT. GAZ. **24**: 197, 198. *pl. 8, figs. 3, 4.* 1897.

SYMPLOCA THERMALIS (Kg.) Gomont. Monogr. des Oscill. in Ann. Sci. Nat. (Bot.) VII. **16**: 114. *pl. 2, figs. 15, 16.* 1892. (*Pl. IX, fig. 14.*)

Stratum dark aeruginous, widely expanded; filaments very rarely pseudo-branched, fragile, densely intricate, crisp; sheath thin; trichomes pale aeruginous, not attenuate at the apex, 1.5–2 μ in diameter; articulations two to three times longer than the diameter of the trichome, rarely somewhat quadrate, 2–5 μ in length; protoplasm homogeneous, rarely containing granules; dissepiments visible; apical cell rotund; no calyptra.

(*a*) Forming extensive layers or knob-like masses on bottom of ditch. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

The appearance of this growth was peculiar. The rich blue-green surface of the layer was marked off into broad ridges of a lighter color, making it resemble very much the ripple-marks left in sand by waves. The filaments are nearly prostrate, taking the direction of the current. It occurred in the same ditch with *Rivularia haematites*, but farther up the hill. The water here is warmer and the current not quite so swift.

PHORMIDIUM LAMINOSUM (Ag.) Gomont. Essai de Class. des Nostocacées homocystées in Morot, Journ. de. Bot. **4**: 355. 1890. Tilden, Am. Alg. Cent. II. no. 181. 1896. (*Pl. IX, fig. 15.*)

Stratum mucilaginous, yellowish, bluish, or bright green, or forming a scurfy, thin, brittle scum with a soft gelatinous cushion underneath; filaments flexuous, densely intricate; sheath not visible; trichomes pale aeruginous, not constricted at joints, with apex straight, briefly attenuate and not capitate, 1.6μ in diameter; articulations longer than the diameter of the trichome,

2.5–3.2μ in length; dissepiments marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow water of spring where the old formation makes a hard, billowy or terraced incline, the algæ extend down the incline for a distance of twenty feet, forming wide ribbons of green alternating with bands of pink, yellow, white, and a darker green. Temperature of spring 91° C. The algal growth occurs at a temperature of 51–55° C. Ribbon Spring, Norris Geyser Basin, Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) In small shallow spring, expanding at top in leaf-like masses, or tapering from bulbous head to a small tubular base. Temperature 55° C. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*c*) In grassy rivulet. Temperature 30° C. Mountain hot springs, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*d*) Around edges of springs. Forming brown and green layers which turn gray or blackish out of the water. Temperature 63° C. Prismatic Lake, Middle Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

(*e*) Forming plumy strings, white or light yellowish in color. Temperature 75.5° C. Solitary Spring, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

(*f*) Forming whitish, scurfy, hardened, rather brittle scum on surface of still pool into which overflow runs. Temperature 41° C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896.

I found this species to be by far the most widespread and abundant of any alga in the hot waters of the park. Its habit of growth is extremely varied, so that it is not easily recognized. It is the only species, except *Spirulina major*, that, so far as I know, is found in both calcareous and siliceous waters in this region.

PHORMIDIUM LAMINOSUM (Ag.) Gomont, forma **Weedii**, n. f. (*Pl. IX, fig. 16.*)

Stratum aeruginous; filaments often strongly bent; sheath not visible; trichomes pale aeruginous, not constricted at joints, with apex sharply bent, briefly attenuate and not capitate, 2.5–3μ in diameter, the dissepiments generally distinct; articulations 1.5–2.5 times as long as the diameter; protoplasm commonly containing granules; dissepiments sometimes marked by granules; apical cell acutely conical; no calyptra.

(*a*) In overflow of channel. Temperature 49–54.5° C. With *Spirulina major*. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W., 1897.

This plant is very near typical *P. laminosum*. The points of difference are that the filaments are slightly greater in diameter, the apex is almost invariably sharply bent and the dissepiments may or may not be marked by granules. Sometimes the entire cell contents are granular.

PHORMIDIUM TENUE (Menegh.) Gomont. Monogr. des Oscill. in Ann. des Sci. Nat. (Bot.) VII. **16**: 169. *pl. 4, f. 23–25*. 1892. Tilden, Am. Alg. Cent. II. no. 182. 1896. (*Pl. IX, fig. 17*.)

Stratum consisting of a thick firm mass, 10–40^{mm} in thickness, upper exposed surface honeycombed, the ridges being thin and papery, and easily crushed; in color surface showed a range between *ferrugineus* and *ochraceus*, the interior between *viridis* and *prasinus;* filaments very long, somewhat straight; sheath delicate; trichomes light aeruginous, straight, constricted at joints, the dissepiments themselves generally indistinct, with apex straight or sometimes bent, not capitate, 2–3μ in diameter; articulations in general 1.5–2 times the diameter, 3–6.4μ in length; protoplasm homogeneous; apical cell acutely conical or bluntly rounded; no calyptra.

Around edges of spring, not covered by water, but water flows in little streams through and around it. Temperature of water 33°C. Lower Geyser Basin, Yellowstone National Park. J. E. T. 29 Je 1896.

PHORMIDIUM RUBRUM Tilden, Am. Alg. Cent. II. no. 186. 1896. (*Pl. IX, fig. 18*.)

Stratum thin, scarlet (*miniatus*); filaments somewhat straight; sheath visible under high powers; trichomes fragile, frequently interrupted, neither attenuate nor curved, not constricted at joints, 1μ in diameter; articulations quadrate or a little longer than broad; dissepiments not or rarely visible.

In overflow from small hillside spring. Water tepid. Between Middle and Upper Geyser Basins, Yellowstone National Park. J. E. T. 2 Jl 1896.

This species is near *P. luridum* and *P. purpurascens*. From the former it differs in not having trichomes constricted at joints. From the latter it differs in not having strongly tortuous filaments nor granulated dissepiments. It is also to be distinguished from both by the color of the stratum and of the trichomes and the length of the articulations.

OSCILLATORIA PRINCEPS Vauch. Hist. Conferv. d'eau douce 190. *pl. 15, f. 2.* 1803. Tilden, Am. Alg. Cent. II. no. 187. 1896. (*Pl. IX, fig. 19.*)

Stratum dark green or black; trichomes 16–19μ in diameter; apex slightly attenuate and shortly arcuate; articulations 4.5–5.5μ long; protoplasm finely granulate; apical cell convex; calyptra none.

(*a*) Forming a black thick floating mass in mountain stream at vent of hot spring; gradually running out, and replaced by green at a distance of fifty feet from vent. Temperature five feet from spring 42°C., fifty feet from spring 38°C. Mountains near Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

(*b*) Forming dark green velvety mass fringing edge of small mountain creek where a hot spring flows out just underneath the bank. Temperature of water one inch below surface 19°C. On surface 58° C. Near Emerald Pool, Upper Geyser Basin, Yellowstone National Park. J. E. T. 3 Jl 1896.

OSCILLATORIA TENUIS Ag. Alg. Dec. **2**:25. 1813. Tilden, Am. Alg. Cent. II. no. 190. 1896. (*Pl. IX, fig. 20.*)

Stratum black or purplish (*atro-violaceus*); filaments dilute

purplish-black (*atro-cyaneus*), straight or somewhat flexuous, constricted at the dissepiments, for the most part 8–13μ in diameter, not attenuate at apex, straight or but slightly arcuate at extremities; articulation 0.25–0.5 times as long as wide, 3–6μ long; protoplasm homogeneous; dissepiments sometimes granulose; apical cell conical, not capitate; no calyptra.

In small mountain spring in a bog, together with moss and watercress. Water tepid. Valley of Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. J. E. T. 28 Je 1896.

OSCILLATORIA AMPHIBIA Ag. Aufzählung, etc. in Flora **10**: 632. 1827. (*Pl. IX, fig. 21.*)

Stratum aeruginous, red or orange colored; trichomes dilute aeruginous, straight or arcuate, fragile, not constricted at dissepiments, 1.5–2μ in diameter, arcuate for some distance at extremities, apex neither attenuate nor capitate; articulations two to three times longer than diameter of trichome, 3–4μ in length; dissepiments sometimes marked by two protoplasmic granules, sometimes not distinct; cell contents granular; apical cell rotund.

Forming lining in channel of spring. Above Beehive Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

The red and orange colors in this material are caused by the presence of bacteria.

OSCILLATORIA GEMINATA Menegh. Conspect. Algol. euganeæ. 9. 1837. Tilden, Am. Alg. Cent. II. no. 191. 1896. (*Pl. IX, fig. 22.*)

Stratum dark green, forming long plumy tufts; trichomes pale aeruginous, densely interwoven, very much constricted at joints, 3.2μ thick; apex straight, not attenuate nor capitate; articulations of unequal length, quadrate or longer than the diameter, 3.2–7μ long; protoplasm containing granules; dissepiments pellucid, not granulated; apical cell rotund; no calyptra.

Covering bottom of creek in swift current. Temperature

47.5°C. Near Upper Geyser Basin, Yellowstone National Park. J. E. T. 2 Jl 1896.

SPIRULINA MAJOR (Kg.) Phyc. Gener. 183. 1843. Tilden, Am. Alg. Cent, II. no. 193. 1896. (*Pl. VIII, fig. 19.*)

Forming a thin brittle scurfy scum, whitish on top; stratum dull green (*prasinus*); trichomes pale green, wound into somewhat straight, dense, very regular spirals with a diameter equaling 3μ, in thickness 1μ; turns contiguous.

(*a*) On surface of still pool into which overflow runs. Temperature 41°C. Mammoth Hot Springs, Yellowstone National Park. J. E. T. 8 Jl 1896,

(*b*) Overflow of channel of geyser. Temperature 49–54.5°C. Spasmodic Geyser, Upper Geyser Basin, Yellowstone National Park. W. H. W. 1897.

(*c*) Forming a whitish brittle scum in the hot water. Beck's Hot Springs. Salt Lake City, Utah. J. E. T. 7 Jl 1897.

This species is quite common in both the calcareous and siliceous waters of the Park. It is generally found with other algæ. I did not find any pure growths.

Spirulina caldaria, n. sp. (*Pl. VIII, fig. 20.*)

Stratum widely expanded, dark aeruginous; trichomes aeruginous, short, somewhat straight and stiff, forming a very lax spiral with a diameter of 1.5μ, 0.9μ in thickness; turns 3.2μ distant from each other.

(*a*) Forming thick richly colored strata on surface of hot water very near outlet of the springs. Natural Sulphur Springs, Banff, Canada. J. E. T. 13 Ag 1897.

SYNECHOCOCCUS ÆRUGINOSUS Næg. Einz. Alg. 56. 1849. Tilden. Am. Alg. Cent. II. no. 195. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 6.* S. 1897.

GLŒOCAPSA VIOLACEA (Corda) Rabenh. Fl. Eur. Algar. **2**: 41. 1865. Tilden. Am. Alg. Cent. II. no. 196. 1896. Described in BOT. GAZ. **24**: 198. *pl. 8. fig. 5.* S. 1897.

CHROOCOCCUS VARIUS A. Br. Rabenh. Alg. Eur. no. 2451 and 2452. Tilden. Am. Alg. Cent. II. no. 198. 1896. (*Pl. VIII, fig. 21.*)

Cells spherical, single or in small groups, 1.6–5.6 μ in diameter; cytoplasm pale aeruginous.

(*a*) On rocks. Near vent of geyser. Sometimes heated. Norris Geyser Basin. Yellowstone National Park. J. E. T. 27 Je 1896.

(*b*) With *Microspora amœna* var. *thermalis*, lying in overflow from spring. Temperature 41° C. Frying Pan Basin. Yellowstone National Park. J. E. T. 7 Jl 1896.

(*c*) Forming a green coating on floor of overflow channel. Temperature 49° C. Constant Geyser, Norris Geyser Basin. Yellowstone National Park. W. H. W. 1897.

(*d*) In acid waters. Green Spring. Between Norris Geyser Basin and Beaver Lake. Yellowstone National Park. W. H. W. 1897.

UNIVERSITY OF MINNESOTA.

EXPLANATION OF PLATES VIII–X.

PLATE VIII.

FIG. 1. *Œdogonium crenulato-costatum* Wittr. var. *aureum*. Filament of female plant showing twin oogonia containing oosperms.

FIG. 2. Filament of male plant with five antheridial cells.

FIG. 3. Apical cell of filament.

FIGS. 4, 5. *Hormiscia flaccida* (Kg.) Lagerh. var. *caldaria*. Filaments with cells of different lengths.

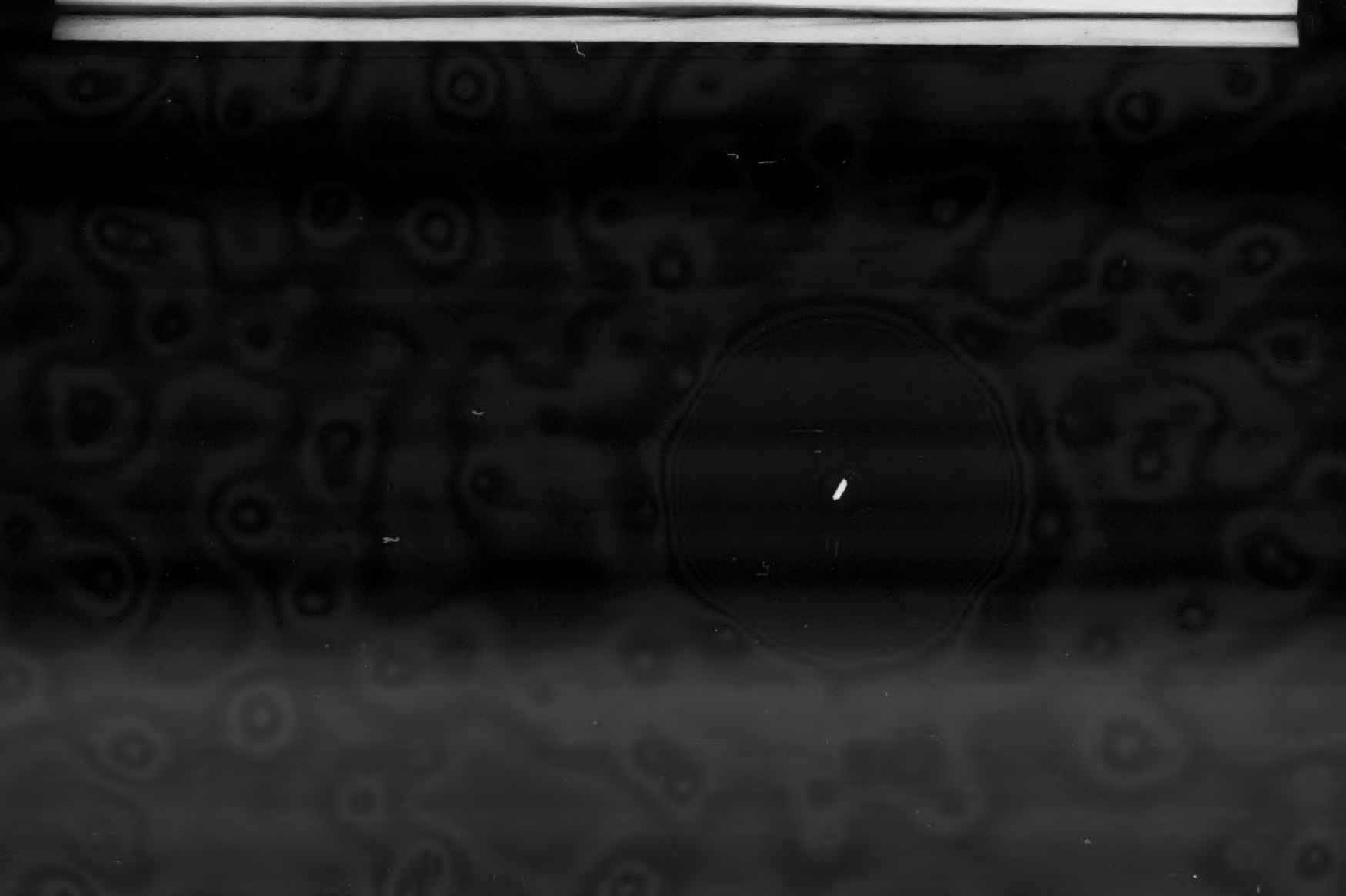
FIGS. 6, 7. *Conferva major* (Kg.) Rabenh. forma *ferruginea*. Filaments of empty cells showing relative thickness of old and new walls.

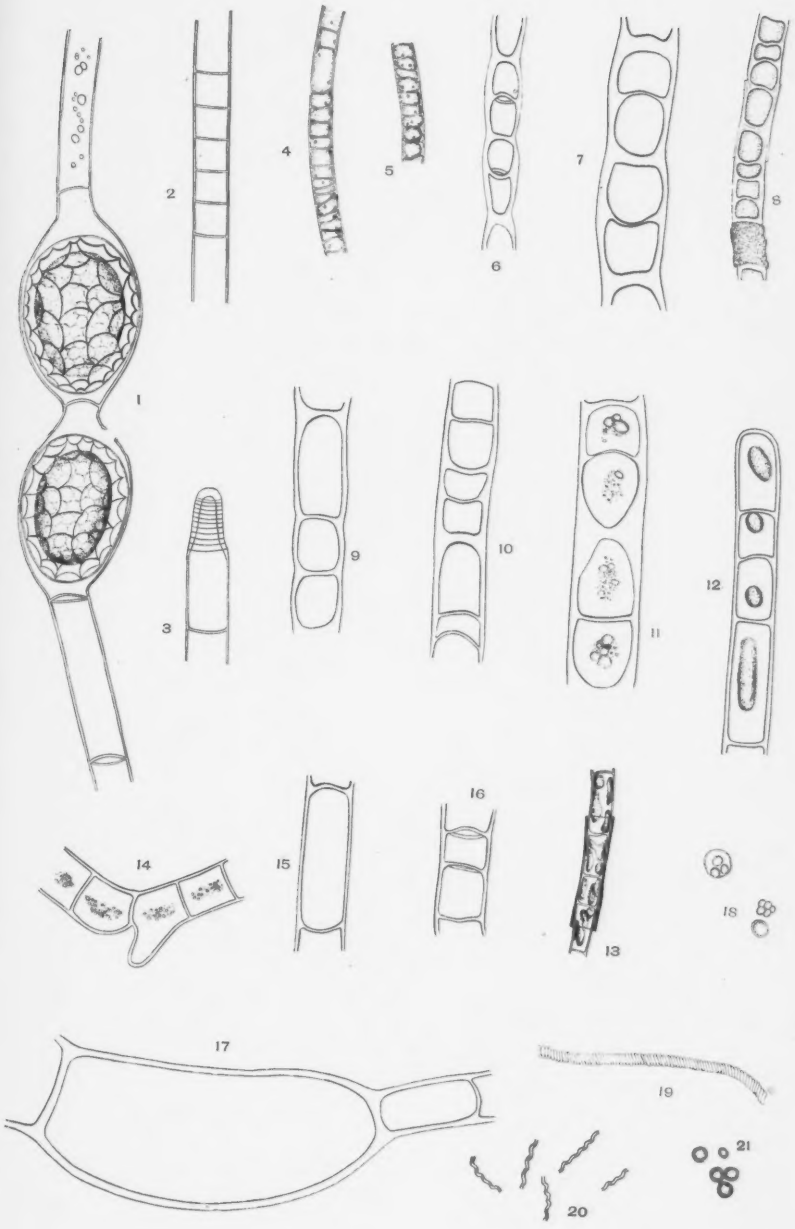
FIG. 8. Filament of same showing cell contents, incrustation of Fe_2O_3 and characteristic appearance of ruptured sheath.

FIGS. 9, 10, 11. *Conferva major* (Kg.) Rabenh. forma *gypsophila*. Filaments giving characteristic appearance of cell wall and cells of different lengths.

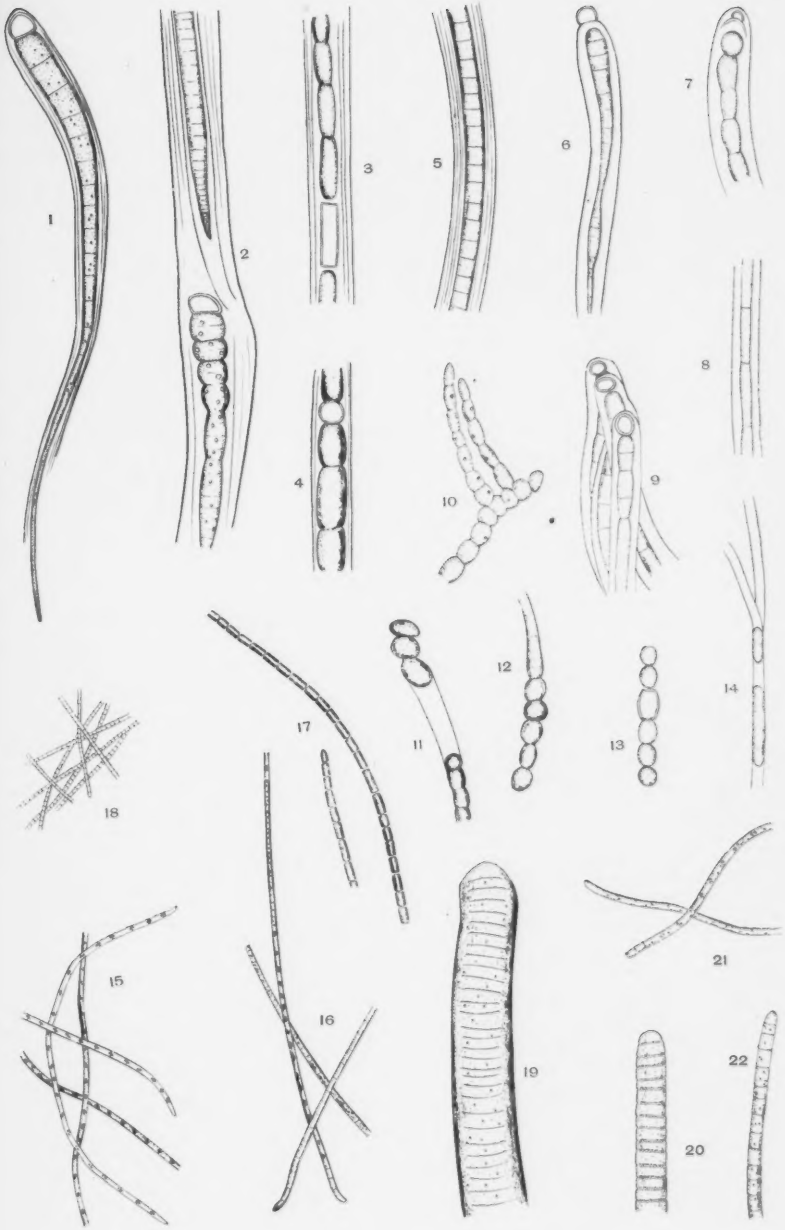
FIG. 12. *Microspora amœna* (Kg.) Rabenh. forma *thermalis*. Extremity of filament.

FIG. 13. *Microspora weedii*. Filament showing cell contents and sheath forming "letter H."





TILDEN on THERMAL ALGÆ.



TILDEN on THERMAL ALGÆ.

TILDEN on THERMAL ALGÆ.

FIG. 14. *Rhizoclonium hieroglyphicum* (Ag.) Kg. var. *atro-brunneum*. Filament showing lateral process and disposition of cell contents.

FIGS. 15, 16. Portions of filaments showing appearance of normal cells.

FIG. 17. Portion of filament showing a distorted cell.

FIG. 18. *Protococcus botryoides* (Kg.) Kirchn. forma *caldarius*. Appearance of cells in process of division.

FIG. 19. *Spirulina major* Kg. Portion of filament.

FIG. 20. *Spirulina caldaria*. Portions of filaments.

FIG. 21. *Chroococcus varius* A. Br. General appearance of cells.

PLATE IX.

FIG. 1. *Calothrix thermalis* (Schwabe) Hansg. Young plant entire, showing basal heterocyst and trichome indistinctly septate.

FIG. 2. Portion of mature filament with branch. The trichome of branch shows well the moniliform character and granular protoplasmic contents.

FIG. 3. Portion of filament with oblong intercalary heterocyst.

FIG. 4. Portion of filament with spherical intercalary heterocyst.

FIG. 5. Portion of filament with articulations as long as wide.

FIG. 6. *Rivularia hæmatites* (DC.) Ag. Young plant.

FIGS. 7, 8. Mature forms showing moniliform and cylindrical trichomes.

FIG. 9. Branching filament.

FIG. 10. *Hapalosiphon major* Tild. Filament with twin branches.

FIG. 11. Filament showing empty sheath.

FIG. 12. Filament showing both moniliform and cylindrical trichome.

FIG. 13. Filament with heterocyst.

FIG. 14. *Symploca thermalis* (Kg.) Gomont. Filament with pseudobranch.

FIG. 15. *Phormidium laminosum* (Ag.) Gomont. Filaments.

FIG. 16. *Phormidium laminosum* forma *Weedii*. Filaments.

FIG. 17. *Phormidium tenue* (Menegh.) Gomont. Filaments.

FIG. 18. *Phormidium rubrum* Tilden. Filaments.

FIG. 19. *Oscillatoria princeps* Vauch. Apex of filament.

FIG. 20. *Oscillatoria tenuis* Ag. Apex of filament.

FIG. 21. *Oscillatoria amphibia* Ag. Portions of filaments.

FIG. 22. *Oscillatoria geminata* Menegh. Apical end of filament.

PLATE X.

A photograph of Solitary Spring, Upper Geyser Basin, Yellowstone National Park. *Phormidium laminosum* forms a part of the algal growth of this spring.

SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY.

ITHACA MEETING, DECEMBER 28–29, 1897.[1]

THE first meeting of the new Society for Plant Morphology and Physiology was held in conjunction with the meetings of the American Society of Naturalists and the affiliated societies at Cornell University, December 28 and 29, 1897. An account of the formation and personnel of this society is given elsewhere in this number. The following papers were presented :

1. *A mycorhiza in the roots of the liliaceous genus Philesia :* DR. J. M. MACFARLANE, University of Pennsylvania.— The author stated that this was the second recorded case of symbiosis between a liliaceous plant and a fungus. The genus Philesia grows in the damp humus soil of west Patagonia, and forms coralloid root masses. The fungus was sparingly present outside the roots, also in the epidermis and exocortex, but formed an abundant growth in the mesocortex, the cells of which rapidly became filled with coiled fungoid hyphæ. The large spherical starch grains of these cells were acted on by the hyphæ, and were dissolved by solution rather than by corrosive action. A large amount of proteid material then appeared in the hyphæ. With growth of the root extremity, the fungus steadily penetrated the mesocortex cells of the growing point, numerous hyphæ being observed in the 10th–12th zone of cells behind the apex. Invariably the crystal cells were left untouched.

The close similarity of the above to cases recorded by Groom for Thismia, and by other authors, was referred to, but

[1] This report is furnished by the Secretary, Professor W. F. Ganong, Northampton, Mass. The abstracts are in all cases by the authors.

the conclusion was reached that while the fungus might for many generations aid the host in the elaboration of protein compounds that were absorbed by the latter, ultimately, though very gradually, the fungus proved a destructive agent.

2. *Studies on some mycelium and fungi from a coal mine :* PROFESSOR GEO. F. ATKINSON, Cornell University.— On the 14th of September the speaker explored abandoned portions of the Algonquin coal mine near Wilkesbarre, Pa., for the purpose of studying the mycelium formations on the doors in the gangways, and on the wood props which are used to support weak places in the roof above. Several flash-light photographs were made of the remarkable displays of the mycelium some four hundred feet below the surface, and of some of the fruit forms. Mature fruit collected has been determined as follows : *Polyporus versicolor*, *P. annosus*, *Coprinus micaceus*, *Stropharia*, *Hymenochæte*, *Merulius*, etc. The paper was illustrated with lantern views.

3. *Is there a basidiomycetous stage in the life-history of some Ascomycetes ?:* DR. E. A. BURT, Middlebury College.— Mr. Burt has been studying a case of undoubted association of *Graphium giganteum* (Pk.), otherwise known as *Dacryopsis Ellisiana* (Berk.) Massee, with the ascomycete *Lecanidion leptospermum* (Pk.), also known as *Holwaya tiliacea* E. & E. *Dacryopsis Ellisiana* was described and figured by Massee as a tremelloid basidiomycete. Mr. Burt has been unable, by the study of collections made in the months of August, October, November, and December, to confirm Massee's observations on the basidiomycetous nature of *Dacryopsis Ellisiana*, and therefore is unable to conclude, for the present, that it is a basidiomycetous stage of the ascomycete *Lecanidion leptosperma*.

4. *Additional notes on the bacterial brown rot of cabbages:* DR. ERWIN F. SMITH, Department of Agriculture.— Field studies of this disease were made in Michigan, Wisconsin, Ohio, and New York in August, September, and October of 1897. These served

to confirm the earlier published statements of the writer[2] respecting the manner of infection and the usual symptoms. A number of new facts which appear to have an important economic bearing were also brought to light. Some of these discoveries are as follows: (1) this disease is serious in many parts of the United States; (2) the greater part of the infections take place through natural openings of the plant, *i. e.*, through water pores located on the serratures of the leaves; (3) the disease is frequently disseminated by insects; (4) the wild mustard, *Brassica sinapistrum*, is one of the common host plants; (5) the disease is very frequently disseminated by man, *i. e.*, by making seed beds on infected soil and transplanting the germs in infected seedlings to land previously free from it; (6) when a soil has once become infected there is reason to believe that the germs are capable of living in it for a series of years and will attack cabbages which are planted on it; (7) the disease may be restricted by planting seed beds on healthy soil; by transplanting, as far as possible, to sod land, or at least to land not previously occupied by crucifers; by destroying wild mustards and parasitic insects; by removing badly affected plants bodily; and in early stages of the disease, *i. e.*, when the disease has only recently passed out of the water pore stage of infection, by removing affected leaves. A full account of the economic aspects of this disease has been published by the Department of Agriculture in the shape of a farmer's bulletin, which may be had on application. Cultures of the parasitic and dried leaves and stems of cabbage showing the characteristic symptoms were passed around.

5. *Occurrence of Kramer's bacterial disease on sugar beets in the United States:* DR. ERWIN F. SMITH, Department of Agriculture. — Attention was called to the existence in parts of the United States (Michigan, Wisconsin, etc.) of a disease of sugar beets much resembling if not identical with that described by Kramer and Sorauer in 1891–2, and more recently by Busse.[3] The

[2] Science **5**: 963. 1897; Centralb. f. Bakt. **3**[2]: 284. 1897.

[3] Zeitschr. f. Pflanzenkr. **7**: 65.

root shrivels in places, becomes very black, and finally breaks down here and there, with the formation of a sticky exudate composed of bacteria. Cultures from the interior of blackened roots remained sterile. Cultures from the syrupy exudate yielded an organism resembling, so far as tested, that described by Busse as the cause of the disease. It is yet too early, however, to say whether the organism isolated is identical with *Bacillus betae* Busse, or whether it is in any sense a true parasite. It appears worth mentioning, inasmuch as it seems to be rather common, and destroys cane sugar, and grape sugar, with the formation of hydrogen, carbon dioxide, and an acid. Possibly this is one of the organisms which has given trouble to the chemists in sugar diffusion work, inverting the cane sugar and liberating gases.[4] Cultures on steamed and raw beets, on steamed potato, and in fermentation tubes were exhibited. On steamed slices of sugar beet there is a copious production of gas.

6. *Are blepharoplasts distinct from centrosomes?:* MR. HERBERT J. WEBBER, Department of Agriculture.—Blepharoplasts, the speaker pointed out, are special organs of the spermatic cells of Zamia, Ginkgo, and some Filicineæ and Equisetineæ, which in certain stages of their development somewhat resemble centrosomes. Two are formed in each generative cell, arising *de novo* in the cytoplasm on opposite sides of the nucleus, and about midway between the nuclear membrane and cell wall. The division of the generative cell results in the formation of two antherozoids, one blepharoplast being located in each antherozoid cell. During this division the blepharoplasts burst and the outer membrane becomes gradually extended into a narrow helicoid spiral band from which the motile cilia of the antherozoid are developed.

The blepharoplasts resemble typical centrosomes: (1) in position, being located on the opposite sides of the nucleus, and (2) in having the kinoplasmic filaments focused upon them dur-

[4] See Jour. Soc. Chem. Ind. **14**:876.

ing the prophases of the division of the generative cell. They differ from typical centrosomes, however, (1) in arising *de novo* in the cytoplasm; (2) in growing to comparatively enormous size; (3) in not forming the center of an aster at the pole of the spindle during mitosis; (4) in having a differentiated external membrane and contents; (5) in bursting and growing into a greatly extended cilia-bearing band, the formation of which is evidently their primary function; (6) in their non-continuity from cell to cell.

7. *Spore formation in some sporangia:* DR. R. A. HARPER, Lake Forest University.—DR. Harper's paper is to be published with some additional material in the near future.

8. *Two new organs of the plant cell:* MR. WALTER T. SWINGLE, Department of Agriculture.—The author announced the finding of two new organs or organoids, the one *vibrioid*, occurring abundantly in the superficial layers of the cytoplasm of some Saprolegniaceæ and some Florideæ; the other being a central body in the developing egg of *Albugo candidus*. The vibrioids are slender cylindric sharply delimited bodies, about the size of many common bacilli, but exhibiting rather slow bending or undulatory proper motions in addition to translatory movements which are probably passive and due to the streaming of the cytoplasm in which they are imbedded. They are fixed well by ordinary killing agents, and when stained are very sharply differentiated from the surrounding cytoplasm. They can also be seen in the living cell. Their appearance suggests that they may be minute endo-parasites, but their constant occurrence in plants in all stages of development and from widely separated localities militates against this view. Their function in unknown.

The other new organoid is a nearly spherical body located at one end of the egg nucleus of *Albugo candidus*. It is often a little flattened on the side adjoining the nucleus, is not very sharply delimited from the cytoplasm, but stains differentially. It seems to be more or less granular in structure, appears just

before delimitation of the egg within the oogonium, and disappears after fusion of the male and female nuclei. It probably plays some part in these two phenomena.

Both of the organoids have been observed before, but were not correctly described by previous writers.

9. *Notes on the archesporium and nucleus of Bignonia:* MR. B. M. DUGGAR, Cornell University.—The mature archesporium of the microsporangia occupies a single boot shaped layer. The primitive archesporium is differentiated by periclinal divisions in certain regions of the outer layer of periblem. The tapetum on the outer side is cut off by the next periclinal divison of the hypodermal layer, and the next division of the latter gives rise to the layer often becoming the fibrillar endothecium of anthers, but in Bignonia there is no fibrillar development. In general, there are no further periclinal divisions in the regions mentioned. The definitive archesporium is formed by not more than a single division in some or all of the primitive archesporial cells. The macrosporic archesporium apparently develops no primary tapetum, divides simultaneously from the two-celled stage, the third or fourth cell becoming the definitive embryo-sac mother cell. The archesporial nucleus, especially, is peculiar in the large nucleolar-like structure which does not stain homogeneously, the outer portion usually taking the violet in the Flemming combination.

10. *Some theories of heredity and of the origin of species considered in relation to the phenomena of hybridization:* MR. WALTER T. SWINGLE, Department of Agriculture.—Owing to limited time the speaker treated only the first portion of his theme, viz., the bearing of the facts of hybridization on some theories of heredity. It was pointed out that Weismann's theory of reduction of chromosomes, though giving a plausible explanation of the differences observed between the first (uniform) and second (polymorphic) generations of most hybrids, is not only in disaccord with the observed phenomena of spore and pollen formation in

higher plants, but fails to account for the extreme polymorphism often observed in the first generation of hybrids between races of cultivated plants, or between closely related species, as for example some racial hybrids of maize and some specific hybrids of Lychnis and Digitalis. Mr. Swingle considered it necessary to assume in some such cases, at least, a predetermination of the characters of the hybrid at the time of fusion of the male and female nuclei. The male and female chromosomes probably persist side by side unchanged in number, and possibly unchanged in quality during the whole of the ontogeny of the hybrid, reduction not occurring until the close of the first generation. It is therefore necessary to assume, in order to explain the observed fact of divergence of character in the first generation of some hybrids, that the influence exerted during ontogeny of the hybrid by the material bearers of heredity is, at least in some cases, a function of their relative positions; and further that in most cases the relative positions of these bearers of heredity, as determined at the moment of fusion of the male and female nuclei, persist unchanged throughout ontogeny of the offspring. Some phenomena, such as reversions to the one or the other parent form by a larger or smaller portion of the hybrid, would be explained by assuming some change in the disposition of the hereditary substance, whereby they assumed a new position of partial or complete stability. The suggestion was made that possibly the difference between uniform and polymorphic hybrids of the first generation is due to a more complete intermingling of the hereditary particles in case of polymorphic hybrids (offspring of closely related organisms), whereby many differing combinations would be possible, and in case of uniform hybrids (mostly offspring of distinct species or very different races of the same species), to greater or less aversion to commingling between the two more diverse sorts of particles, whereby they would remain in two separate groups and affect ontogeny uniformly and equally.

Xenia, or the communication of paternal characters to parts of the mother plant in the immediate neighborhood of the devel-

oping embryo, was held to be well established in case of some races of maize by the work of Dudley, Savi, de Vilmorin, Hildebrand, Körnicke, Sturtevant, Burrill, Kellerman and Swingle, McCluer, Tracy, Hays, and others, and in case of some races of peas, by the work of Wiegmann, Gärtner, Berkeley, Laxton, and Darwin. The converse phenomena of the mother plant influencing the characters of the developing embryo are occasionally reported, for instance in hybrids of Digitalis by Gärtner, and in hybrids of Nymphæa by Caspary.

These phenomena are inexplicable by most of the current theories of heredity and perhaps in consequence have been neglected. They necessitated the assumption that hereditary influences can be transported from cell to cell for some distance. The suggestion was made that this transport may occur either along the intercellular filaments which pass through the walls, or by means of diffusible substances capable of acting on the hereditary particles of distant cells. Townsend's proof of the conduction of the stimulus which results in wall formation, over long slender threads of protoplasm in plasmolyzed cells, may be considered as hinting at the possibility of the former explanation, while Beyerinck's claim, that the developing larvæ of some gall insects secrete substances which diffuse into and control the ontogeny of neighboring meristematic or partially developed tissue cells of the host plant, furnishes some ground for the latter hypothesis.

11. *The variable effects of hydrocyanic acid gas on plants and animals:* MR. ALBERT F. WOODS, Department of Agriculture.— Plants of various families and in different stages of growth were subjected to varying amounts of hydrocyanic acid gas, and were found to be affected by it in different degrees, according to the kind of plant, its age, and other conditions of growth and development. Animals, mainly insects, were also found to vary, even within the same family, in like manner. Mites were the most resistant of any of the organisms studied, often recovering after several hours of complete paralysis and apparent death.

12. *Effect of alternating dryness and moisture on the germination of some seeds:* MR. A. J. PIETERS, Department of Agriculture.—The experiments recorded are preliminary to more extensive ones now in progress, but they show clearly that for some seeds germination is quickened by thorough drying after a long period of dampness. In most cases, after a small percentage of germination for the first one hundred days or more, drying for two weeks, followed by wetting, resulted in a germination of from 15 to 54 per cent. in a few days. In the check pots, meanwhile, the seeds either did not germinate, or only a small percentage did so.

13. *Experiments on the morphology of Arisæma triphyllum:* PROFESSOR GEO. F. ATKINSON, Cornell University.—Female, male, and neuter plants, the history of which was known by growing them in pots for one season, were potted, some in rich soil and others in poor soil, the object being to change them from male to female, etc., by varying amounts of nutriment. Male plants in rich soil were in one year changed to female, and large neuter plants in rich soil were changed to female.

In a second series, large two-leaved female plants, with large bulbs, were selected at the time the fundament of the flowers was formed. The bulbs were cut so as to remove all but a small portion in connection with the bud. By this removal of the larger part of the stored food the plants were changed to male.

14. *On polyembryony and its morphology in Opuntia vulgaris:* Dr. W. F. GANONG, Smith College.—The author has found this species markedly polyembryonic, the polyembryony having a double morphological basis. One set of embryos comes from a mass of tissue which appears to develop from the fertilized egg cell, the others spring from the wall of the embryo sac, but not from the nucellus, and probably arise from endosperm cells, which if true is a mode hitherto unknown. The literature of the subject was summarized and some remarks given upon the significance of polyembryony.

15. *Contributions to the morphology and biology of the Cactaceæ. Part II.— The comparative morphology of the embryos and seedlings:* Dr. W. F. Ganong, Smith College.— This paper is a continuation of the author's earlier studies upon this family. It describes and figures germinated embryos of most of the genera and many important species, discusses the germination and growth of the embryos, their form- size- and color-factors, and the features they show of importance for the determination of the phylogeny of the genera, the development of the seedlings, and the unfolding of the peculiar morphological features of the adult plants.

16. *The morphological significance of the lodicules of grasses:* Dr. W. W. Rowlee, Cornell University.— A study of the flowers of the bamboos leads to the conclusion that the lodicules of grasses represent a reduced perianth. The three lodicules in the flower of Arundinaria alternate on the axis with the stamens, and may therefore be considered the inner whorl or petals. The stamens are directly opposite the midribs of the carpels and indicate that the inner whorl of stamens, present in some bamboos, is suppressed in Arundinaria. Hackel, as is well known, interpreted the lodicules as distichous bracts.

17. *Observations on the American squaw-root* (*Conopholis Americana* Wallr.): Dr. Lucy L. W. Wilson, Philadelphia.— An exhaustive study of the vegetative and reproductive parts had been made, but an account of the former only was read. The invariable host plant was the oak. The extreme degradation of the parasite, and the intimate relation between it and the oak roots caused the author to compare it with members of the Balanophoreæ and Rafflesiaceæ, rather than with parasitic members of the Scrophulariaceæ. The seedling parasite seemed early to attack young oak roots, and steadily grew for ten to twelve years, until a huge mass six inches across might be formed. This mass was chiefly characterized by the abundance of sclerenchyma patches, developed by the oak host through the irritant

action of the invading parasite. The presence of stomata on the stem and their absence on the scale leaves was pointed out, while the double circle of bundles traversing the flowering stem was peculiar in that the xylem of these faced each other.

18. *Water storage and conduction in Senecio praecox from Mexico:* DR. JOHN W. HARSHBERGER, University of Pennsylvania.—*Senecio praecox* (Cav.) DC. is a composite plant inhabiting the volcanic beds of the valley of Mexico. It has a cylindrical, succulent, woody stem rising three or four feet from the ground, with clustered deeply lobed leaves at the top. The plant stores up an abundant supply of water in the pith, which is gradually used up during the dry season in Mexico, which lasts from October to June. The flowers develop in April at the expense of the reserve supply of water. Loss of water during the dry season is prevented by the fall of the leaves, and by protective cork and balsam, the latter secreted in the exocortex and endocortex. The water, stored in turgid disks of pith, is gradually conducted by the woody cells and tracheids which penetrate into the medulla by wedge shaped ingrowths, representing the primary bundles, to the growing point where it is used. That this is the case is shown by the dry parchment-like pith membranes which were left in a piece of a stem which had remained in the dry state for over sixteen months. Conduction of water in this stem was accomplished without assistance of root pressure, and without any appreciable influence on the part of the small green leaves in drawing up the liquid by aid of the transpiration current.

19. *Notes on the embryology of Potamogeton:* MR. K. M. WIEGAND, Cornell University.—*Potamogeton pauciflorus* was studied with reference to the origin and development of the embryo sac, fertilization, and development of the embryo. The embryo sac was found to arise in the usual manner for monocotyledons, viz., from the subepidermal cell after the cutting off of a tapetal cell. The egg apparatus and antipodals were,

however, somewhat abnormal. Although the normal number of cells in each was present, they were formed irregularly. The polar nucleus and first and second synergids seem to have been cut off successively from the mother nucleus of the egg. The synergids disappear almost immediately. A similar irregularity was found in the antipodals; but the most interesting feature, perhaps, was the fact that the definitive nucleus cuts off a very large basal nucleus, as in Sagittaria, before endosperm formation proceeds in the upper part of the sac.

20. *Recent experiments and observations on fruit production in Amphicarpæa:* DR. ADELINE SCHIVELY, Philadelphia Normal School.—This paper detailed the author's recent studies on the hog peanut (*Amphicarpæa monoica*). Her published observations showed that minute aerial cleistogamous flowers, when buried, produced one-seeded "nuts" with soft fruits and seed coats, instead of the two to three-seeded pods with indurated walls. She now showed that when purple flowers were buried in the bud state, while still attached to the plant or at any period up to the time of fertilization, perfect underground "nuts" matured, instead of three to four-seeded indurated pods. Various conclusions were drawn as to the powerful action of environmental agents in determining the size, shape, and consistence of the seed, the induration of its coats, and the number of seeds that might be produced.

21. *On the formation of cork tissue in roots of the Rosaceæ:* DR. MARTHA BUNTING, Philadelphia High School.—Starting from observations on *Geum urbanum* and *G. rivale*, made by Professor Macfarlane in 1890, when intercellular spaces were shown to exist between cork cells, Dr. Bunting proved this condition to be typical for all herbaceous and shrubby species examined, but to be absent in roots of arborescent species. She described the alternation of a flattened, usually pigmented layer of cells, with one to three layers of rounded cells in each annual ring, the flattened layer being the last produced each season. Protoplasm,

nuclei, and starch grains existed in cork zones four to five layers removed outside the phellogen.

22. *The structure and developmant of internal phloem in Gelsemium sempervirens:* MISS CAROLINE THOMPSON, University of Pennsylvania.—The author showed that the internal phloem originated as four longitudinal tracts in the primary meristem, and steadily increased until by the eighth or tenth year it had entirely pressed together and destroyed the pith. During the first year nourishment of the pith ceased, owing to the differentiation of two layers of cells, which were referred to as the "phloem sheath."

A remarkable distribution of the internal phloem was shown to exist in the petiole, at the base of which a bicollateral bundle arrangement existed, but this quickly changed to the ordinary collateral relation by the passage of the upper (internal) phloem through the xylem of the petiole. Each bundle in passing out into the petiole subdivided into three parts, two of which remained in the stem and soon came together again, while the third passed out and behaved as above described.

From the second year onward, the internal phloem patches of the stem show areas of crushed and obliterated tissue, where the previously formed phloem had been pushed inwards by the younger elements. In older stems eight large phloem patches, formed by division of the original four, entirely filled up the pith area.

BRIEFER ARTICLES.

THE TREE OPUNTIAS OF THE UNITED STATES.

THREE species and two varieties of the cylindrical opuntias of the United States may very properly be termed trees. The species and varieties here designated are *O. fulgida* Engelm., *O. fulgida mammillata* (Schott) Coult., *O. versicolor* Engelm., *O. spinosior* (Engelm.),[1] and *O. spinosior neomexicana*, var. nov.[2]

O. fulgida is a well-marked species with characters constant and well defined. There is little danger of mistaking this species for others when it is once known. The specific characters of *O. fulgida* are substantially as given by Dr. Engelmann.[3] Although this species has been found as far north as southern Nevada,[4] within the borders of the United States it is confined almost entirely to Arizona, south of the Colorado plateau.[5] It is a plant of the plains and evidently reaches its greatest development on the mesas about Tucson, at an elevation of

[1] **Opuntia spinosior** (Engelm.) (*O. Whipplei spinosior* Engelm. Syn. Cact. 307. 1856).—A small tree 25 to 35^{dm} high, trunk 12 to 25^{cm} in diameter, with dark brown, thick, rough bark, with numerous very spiny verticillate branches forming a spreading top: joints cylindrical, varying in color from green to purple, ultimate ones 5 to 20^{cm} long, about 2^{cm} in diameter, the short, broad, prominent tubercles slightly crested, elevated 3 to 6^{mm} and from 8 to 14^{mm} long: pulvini oval, with short, light colored wool and a few short light-brown bristles at upper margin: spines 5 to 15 on ultimate joints, 30 to 50 on older joints, 5 to 15^{mm} long, the interior ones occasionally longer, closely sheathed, reddish-brown, the sheaths white and glistening: the flower purple, 5 to 7^{cm} broad, with broad obovate petals: fruit in whorls at extremity of branches, oval rarely globose or hemispherical, 3.5^{cm} long and 2.5^{cm} in diameter, bearing about 25 tubercles, unarmed, fleshy, with acid flavor, yellow: seeds regular, smooth, 4^{mm} broad, with linear commissure.

[2] OPUNTIA SPINOSIOR **neomexicana**, var. nov.—Growing with and of the same size as the species: tubercles longer: spines more numerous and looser sheathed: flowers yellow to red, with petals much narrower and fewer than in the species: fruit longer and frequently tinted with red.

[3] Cactaceæ Mex. Bound. 57.

[4] Contributions from U. S. National Herbarium **3**: 448.

[5] Garden and Forest **8**: 324.

from 2000 to 3000 feet. Here an occasional specimen is found with trunk twelve inches in diameter three feet above the ground, and bearing a well formed top with wide spreading branches.

The bark of the trunk and larger limbs is thick, rough, and entirely destitute of spines, the spines falling away with the outer layers when the branches are about four inches in diameter. It varies in color from almost black to yellowish brown, depending upon its thickness and age. The terminal joints are very succulent and almost devoid of woody tissue. They are easily detached and usually develop roots after falling to the ground, establishing themselves as independent plants.[6] The tubercles on a joint of the first season's growth bear from five to fifteen loose-sheathed spines, but in common with many other species of cylindrical opuntias, several spines develop at the upper margin of each pulvinus during the season's growth, so that a tubercle on a stem several years old may bear as many as forty or even sixty well developed spines.

In Dr. Engelmann's description and in the account of this plant as given by most writers the flowers are said to be purple. They are, however, purple only when dried or withered. In fresh condition they are bright pink. The plant of Lower California referred to this species is said by Mrs. Brandegee to have yellow flowers.[7] When fully open the short petals are strongly reflexed. In Arizona this plant does not bloom until July, and from this time flowers may be found until late in September. The early flowers develop from the tubercles at the ends of the joints of the previous year's growth, while the later ones grow from the terminal tubercles on the immature fruit. This process may go on through six or seven series during the months of July, August, and September until the proliferous fruit hangs from the stems in pendulous clusters, sometimes as many as seven fruits in a single cluster, one growing from the other in continuous succession.

Occasionally a fruit will remain attached to the plant for the second year, and flowers develop from the tubercles of the old fruit. In a few instances I have found a branch growing from a tubercle on a normal fruit. If a fruit not fully ripe be placed on moist sand, roots will grow from the lower tubercles and either flowers or branches from the upper ones, forming an independent plant without the growth of the seeds within. Fruits attached directly to the stems are usually larger and

[6] Vegetal dissemination in Opuntia, BOT. GAZ. **20** : 356.

[7] Notes on Cacteæ, Erythea **5** : 122.

contain perfect seeds, while the secondary ones are generally sterile; however, an entire cluster may sometimes be found with perfect seeds.

Cattle feed upon the succulent spineless fruits, but in doing so the burr like terminal joints frequently become detached and adhere to their heads, the innumerable barbed spines piercing the flesh and causing injurious wounds if not removed. Many small bristles cover the pulvini of the fruit at maturity and accumulating in the stomachs of the cattle feeding upon them produce large phyto-bezoars. In color the fruit at maturity is pale green, a little lighter shade than the epidermis of the stem or immature fruit.

The plant illustrated in *Garden and Forest* **8**: 325 was removed some eighteen months ago from the mesa to the cactus garden of the University. Although the plant is one of the largest specimens in this vicinity and at least one hundred years old, it did not seem to suffer from transplanting. In this specimen the entire root system, with the exception of a few long surface roots, was a mass of short fibers springing directly from the trunk a few inches below the surface of the soil, none reaching to a greater depth than two and one-half feet.

What has been said of *O. fulgida* applies almost equally as well to *O. fulgida mammillata*. The differences seem to be in that the variety has thicker, shorter joints; fewer, shorter spines; more prominent, shorter tubercles; and is a plant of the foothills instead of the open mesa.[8] The description as given by Dr. Coulter[9] gives the variety as more tree-like than the species. In my observations the reverse is true. Although the spines on the terminal joints are usually four to six, older ones may have twenty or thirty to the tubercle. The flowers and fruits are practically identical.

O. versicolor Engelm. is the most abundant cylindrical opuntia on the foothills and low mountains of southern Arizona. It is a small tree with trunk eight inches in diameter in well developed specimens, and bearing many irregular branches with terminal joints sometimes two feet in length. It has smooth, light-brown bark, without spines on the trunk and older limbs. The epidermis of the younger branches is dark-green to purple. The terminal joints are intermediate in diameter between *O. spinosior* and *O. tetracantha*, while rather prominent tubercles are intermediate in length between *O. arborescens* and *O. spinosior*.

[8] Garden and Forest **8**: 324.

[9] Contributions from the U. S. National Herbarium **3**: 449.

The short, brownish spines have inconspicuous sheaths and vary in number from four to fourteen on young joints, while on older stems there may be as many as twenty-five to a single tubercle. The flowers appear in May, expanding to nearly an inch and a half in diameter, the comparatively narrow petals varying in color from greenish-red to greenish-yellow.

The fruit ripens from December to February, usually withering and drying on the tree. Sometimes it does not dry but remains fleshy, adhering to the branches until late the next summer or in some instances for longer than two years. At maturity it frequently splits open, showing the many angular seeds within. It is not unusual for fruits that remain to become proliferous the second season. It varies remarkably in size and shape, but is usually pear-shaped and from one to two inches in length. A form of this plant growing on the foothills of the Santa Catalina mountains bears fruit less than three-fourths of an inch in diameter and almost perfectly spherical. The color of the mature fruit is the same as that of the stems, never yellow as in related species. The pulvini are all toward the apex of the fruit, and usually growing from them are one to three reflexed, persistent spines a half inch or less in length. In many specimens, however, the fruit is spineless. The seeds are irregular and angular, a character common to species with dry fruits.

Considerable confusion exists regarding the geographical distribution and specific characters which separate *O. Whipplei* Engelm., *O. arborescens* Engelm., and *O. spinosior* (Engelm.), the latter an intermediate species heretofore considered as a variety of *O. Whipplei*. *O. Whipplei* is a species of the Colorado plateau,[10] growing at an elevation of from 5000 to 7000 feet. As I understand this species I have never found it growing south of this plateau. In Dr. Engelmann's account of this plant,[11] under the brief description of the variety we are referred for illustration to *pl. 17, figs. 1–4*. Turning to this plate the figures indicated are marked *O. Whipplei*. The illustration is an excellent representation of the plant of the Colorado plateau and unquestionably represents the species instead of the variety. In the description of the species we are referred to *pl. 17, figs. 5–6* and *pl. 17, fig. 4*. Turning to these plates we find the figures marked *O. arborescens*. Here again there is confusion, but by comparing the plant of southern Arizona with these illustrations I conclude that they were made after

[10] Garden and Forest 9: 2.

[11] Pacific R. R. Report 4: 51.

material collected here and really represent what has been known as *O. Whipplei spinosior* Engelm.

O. Whipplei is a low, spreading bush, never arborescent and rarely more than two or three feet in height. The joints are usually somewhat clavate, and the spines are covered with white, glistening, loose sheaths, which gives the plant a characteristic appearance and readily separates it from related species. The flowers are not red as stated by Dr. Engelmann and followed by Dr. Coulter in his preliminary revision, but a yellowish-green, and when fully expanded barely an inch in diameter. From the original account of the species and variety I infer the description of the flower was drawn from material collected by A. Schott south of the Gila river, and represents the plant designated as the variety *spinosior*, which has much larger purple flowers. The fruit of *O. Whipplei* is hemispherical and less than an inch in diameter. It ripens during the winter months and usually shrivels and dries on the plant.

O. spinosior is not only specifically distinct from *O. Whipplei*, but has a well marked variety in southern Arizona, viz., *O. spinosior neomexicana*. This southern species and variety are low growing trees with spreading tops. By most writers the species has been confused with *O. arborescens*. In my account of *O. arborescens*[12] the plant illustrated is really *O. spinosior*, while the form with smaller flowers having fewer and narrower petals varying in color from red to yellow is the above variety.

The flowers and fruit of *O. spinosior* are practically the same as in *O. arborescens*, but the two species are readily separated by the long, high crested tubercles of *O. arborescens* when compared with the short almost mammillate ones of the former species. The latter species is a much smaller and more eastern plant, never approaching a tree in size, at least in the United States. I have measured specimens of *O. spinosior* in the vicinity of Tucson with trunk two feet from the ground a little over nine inches in diameter. The plant grows with *O. fulgida* on the open mesa, seldom reaching the foothills, where its place is taken by *O. versicolor*. The trunk and larger limbs are spineless, but are covered with thick, rough, dark-brown bark in elongated ridges. The flowers appear in April and May, and the fleshy fruit ripens during the following winter and spring. The large, conspicuous, deep-purple or magenta flowers, like all other species of this section known to me,

[12] Garden and Forest 9 : 2.

have sensitive stamens, which, when disturbed close tightly around the style a few lines below the stigma.

An average fruit has from twenty to thirty tubercles, at first armed with a number of slender spines, which are deciduous in November and December, when the fruit begins to turn yellow.

The tubercles of the immature fruit are very prominent, but as the fruit ripens it increases considerably in size, becoming more succulent, and as a result the tubercles become much less conspicuous, sometimes entirely disappearing, leaving the fruit smooth save for the small bristle covered pulvini. The oval fruit when ripe is frequently two inches long, and one and one-half inches in diameter, well filled with smooth seeds similar to those in *O. arborescens*. As with *O. versicolor* the fruit occasionally remains green for the second year and becomes proliferous. It is clustered at the extremity of the stems of the previous year's growth, and when ripe the verticillate branches are pendulous from its weight.

The variety grows with the species, and its general form and habit of growth is somewhat similar.—J. W. TOUMEY, *University of Arizona.*

WINTER CHARACTERS OF CERTAIN SPORANGIA.[1]

(WITH PLATE XI)

THE gross characters of winter buds have been studied for a long time, but the histological characters of the sporangia have received comparatively little attention. It is an unfortunate fact that many otherwise excellent morphological papers are marred by incompleteness, and perhaps this is nowhere more apparent than in the case of those sporangia which attain some degree of development before the winter sets in, pass the cold season in a quiescent state, and resume development in the spring. It is hoped that the description of a somewhat miscellaneous collection of sporangia will not only show in what condition many buds pass the winter, but will incidentally enable students to make their series complete without waiting until the next year to fill in the gaps. The study of these dormant sporangia may also throw some light upon the significance of the resting stages of nuclei and cells. All the material upon which the following observa-

[1] Contributions from the Hull Botanical Laboratory. VIII.

tions are based, excepting Marsilea, was collected in the vicinity of Chicago.

OSMUNDA CINNAMOMEA L. — Rhizomes with strong buds were dug up November 11, 1897, the woolly covering was removed, and small parts of fertile branches were killed in chrom-acetic acid. The entire absence of mitotic figures showed that cell division had ceased. The average condition of the sporangia is shown in *fig. 1*. The sporogenous tissue has reached the spore mother cell stage, but the cells are still sharply angular, not yet showing any tendency to assume the spherical form which precedes division into tetrads. The cytoplasm is dense and not at all vacuolated. None of the nuclei show synapsis, but the chromatin is evenly distributed. There are usually two or three nucleoli. Some of the nucleoli are cyanophilous and others erythrophilous, even in the same nucleus, but on the whole one kind or the other predominates in any given sporangium. In both kinds there is considerable variation in the intensity of the stain, an indication that the nucleoli are undergoing changes. The tapetal cells, while rather poor in contents, are not breaking down like the cells between the tapetum and the epidermis.

MARSILEA QUADRIFOLIA L.— In the mature sporocarps collected November 10, after the leaves had rotted, both microspores and macrospores had nearly reached their full size, but were still uninucleate, germination under natural conditions not beginning until the next spring.

SELAGINELLA APUS Spring.—The development is carried further than in Marsilea, the prothallium attaining considerable size before the macrospore is shed.

PINUS LARICIO Poir.—Several stages were studied. Microsporangia gathered in October, January, and the following April are represented in *figs. 2, 3* and *4* respcetively. All are in the spore mother cell stage. This may be known by the fact that in a section of a sporangium the number of cells within the tapetum corresponds with the number of tetrads in late April sporangia. Guignard's rule that when the tapetum is differentiated the sporogenous tissue has reached the spore mother cell stage is sustained by all the microsporangia which I have examined. In October specimens (*fig. 2*) the spore mother cells have several small nucleoli which are quite uniformly cyanophilous. In the January material (*fig. 3*) the nucleoli are very inconspicuous, but reappear as the nuclei resume their growth in the spring (*fig. 4*). This figure shows three nuclei in synapsis, while the other nuclei have

the large size and prominent chromatin network which marks approaching division. The tapetum, now much compressed by the growing spore mother cells, is more sharply marked than in the January preparations. Collections of May 4 had the macrospore developed almost to the formation of archegonia.

PINUS BANKSIANA Lambert.— About a dozen macrosporangia, collected May 14, showed the macrospore mother cell, but material collected in a neighboring locality two weeks earlier showed an endosperm of several cells. Mitotic figures are very frequent in all of these spring collections, so that it is very possible that the macrosporangia also pass the winter in the spore mother cell stage.

CUPRESSUS LAWSONIANA Murray.— October microsporangia showed pretty uniformly the condition represented in *fig. 5*. The nuclei of the spore mother cells usually have a single prominent nucleolus which which is cyanophilous. No macrosporangia were studied.

TAXUS BACCATA CANADENSE Willd. — The microsporangia had reached the spore mother cell stage in October (*fig. 6*), but the nuclei were still rather small in comparison with the size of the cell. The tapetum is sharply differentiated, and its cells show no tendency to plasmolyze like the other cells of the sporangium wall. The macrosporangia were not studied.

TRILLIUM. — Miss Arma Smith[2] found microsporangia of Trillium in the spore mother cell stage in buds taken from beneath the frozen soil on April 5. In one case the mother cells were undergoing division. This suggests that cell division, which I feel certain does not take place under our usual winter conditions, may be resumed while the temperature is still near the freezing point. The present writer found the four potential macrospores in *T. recurvatum* collected April 10, at which time the plants were about two inches high.

HEPATICA ACUTILOBA.—Mottier[3] reports that material of this species collected in the middle of November was already too far advanced for studying the earlier stages of the embryo sac. Some of my material collected September 27 was young enough for the study of floral development, while the largest buds showed microsporangia in the pollen mother cell stage. Another collection taken in the spring while the ground was still frozen had pollen fully formed and embryo

[2]Abortive flower buds of Trillium. BOT. GAZ. **22**: 402. 1896.

[3]Contributions to the embryology of the Ranunculaceæ. BOT. GAZ. **20**: 298. 1895.

sacs ready for fertilization. It hardly seems probable that a macrosporangium would pass the winter in this stage.

SALIX.—Two years ago I studied a very complete series of microsporangia and macrosporangia in Salix[4] This series, containing sporangia collected in nearly every month of the year, showed that the microsporangia pass the winter in the spore mother cell stage. The midwinter pistillate flowers showed considerable variation; in some even the rudiment of the nucellus could not be distinguished, while in others the archesporium may have been present. Undoubted macrospore mother cells were not found until growth had been resumed in the spring.

POPULUS.—This genus shows practically the same conditions. Staminate flowers of *P. monilifera* Ait. collected in July showed the primary sporogenous cell. In October the sporangia had reached the spore mother cell stage, and could hardly be distinguished from the midwinter condition represented in *fig.* 7. No undoubted macrospore mother cells were found until growth had been resumed in the spring.

CORYLUS AMERICANA Walt.—Midwinter catkins showed the pollen grains apparently ready to be shed. The division into the tube nucleus and generative nucleus had already taken place (*fig.* 8).

ALNUS GLUTINOSA Willd.—This species showed about the same conditions as the last. The winter microsporangia appear so nearly like those collected just before the shedding of pollen in the spring that one figure might represent them both (*fig.* 9).

These examples are sufficient to show that sporangia of various plants pass the winter in very different stages of development, and it seems probable that all plants of a given species in a given locality pass the winter in about the same stage of development.

The spore mother cell seems to be a very usual halting place in the development of sporangia, but whether this is because the spore mother cell is better able to withstand unfavorable conditions, or for some other reason, it is at present impossible to decide. It has been noted by cytologists that the spore mother cell, in which the reduction of chromosomes takes place, requires a longer resting period than do the cells which precede or follow it. This may be seen even in annuals where the resting period is comparatively short, and is easily observed in those biennials and perennials which pass through all stages from floral development to seed in a single season. It is certain, however,

[4] Contributions to the life history of Salix. BOT. GAZ. **23**: 147–178. 1897.

that so long a period is not needed, since many plants which have reached the spore mother cell stage in the autumn resume their development when brought into the laboratory early in the winter. Again, my observations hardly allow the supposition that the sporangia merely continue their development until checked by cold weather. Of course every botanist has noticed dandelions blossoming in December and January, and fruit trees bearing a second set of flowers in late autumn. The change in the habits of north temperate plants when taken to a warmer climate is also well known, but they doubtless still have their resting periods. I should be inclined to think that the stage at which a sporangium rests for the winter is determined largely by its power to withstand unfavorable conditions. It has been noticed that the later the material is collected the more promptly it resumes its development. This suggests that the resting period is not one of absolute inactivity.— CHARLES CHAMBERLAIN, *The University of Chicago.*

EXPLANATION OF PLATE XI.

All figures are drawn with a Bausch and Lomb camera lucida, Zeiss ocular no. 2 and Zeiss apochromatic 2^{mm}, homogeneous immersion objective. The figures have been reduced by photography to one-half the size of the original drawings.

FIG. 1. Sporangium of *Osmunda cinnamomea* L. collected November 11, 1897.

FIG. 2. Microsporangium of *Pinus Laricio* Poir. collected October 1, 1896.

FIG. 3. The same, collected January 3, 1898.

FIG. 4. The same, collected April 4, 1896.

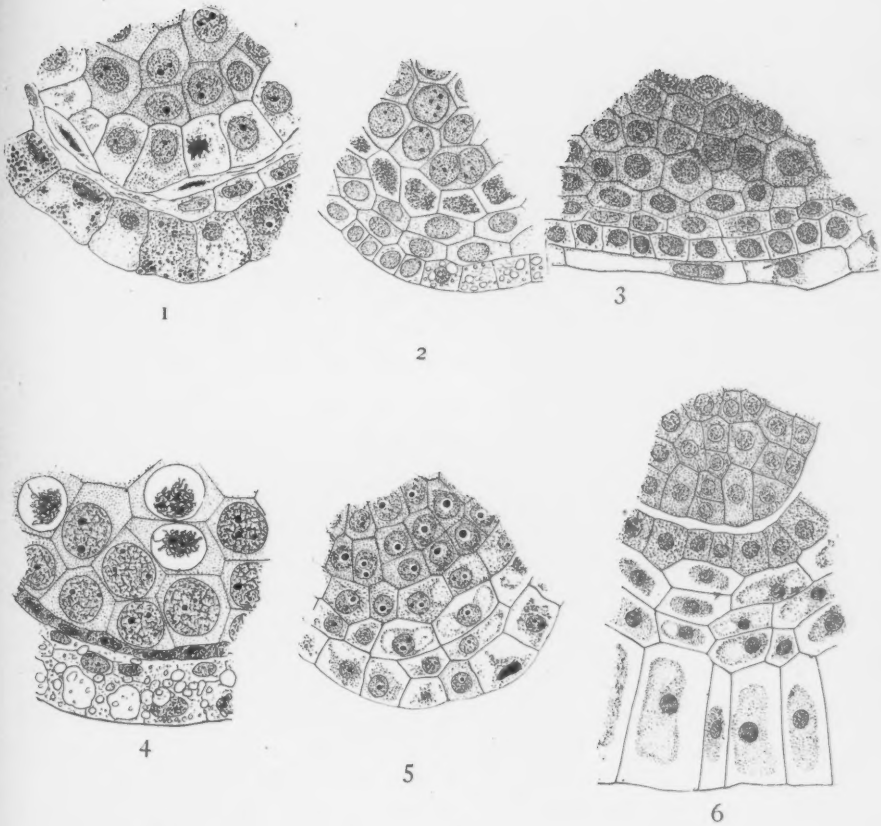
FIG. 5. Microsporangium of *Cupressus Lawsoniana* Murr., collected October 1, 1897.

FIG. 6. Microsporangium of *Taxus baccata, Canadense* Willd. collected October 1, 1897.

FIG. 7. Microsporangium of *Populus monilifera* Ait. collected January 25, 1896.

FIG. 8. Microsporangia of *Corylus Americana* Walt. collected December 7, 1897.

FIG. 9. Microsporangium of *Alnus glutinosa* Willd. collected April 12, 1897.



CHAMBERLAIN on WINTER SPORANGIA.

EDITORIALS.

The Standpoint of Criticism

As the number of botanists in this country increases it is inevitable that they will cross each other's paths more and more. Up to the present each worker, except in taxonomy, has been more or less independent, and what he has had to say regarding any given subject has been accepted by his fellows, for the time at least, as substantially correct. In taxonomy, however, the number of workers has been greater; their views have conflicted, as from the very nature of the subject, they must; and from the criticisms of each other's work a considerable amount of coldness or even aversion has been engendered. In Germany one sees this condition in its extreme development; scientific men refusing to speak to those who antagonize their views on controverted points, or even absenting themselves from societies whose meetings are attended by the obnoxious opponent.

No one can believe that American botanists wish such a state of affairs to exist here. That being so, it will be well for each to exercise caution in the matter of unfavorable criticism which he may be called upon to make upon the work of his associates. It seems clear that not only the right but often the duty to pass such criticism must be maintained. It becomes a question therefore of the manner and the standpoint of criticism. As to manner, it is to be assumed that this will not pass the bounds of courtesy in the future, as it has rarely done in the past. Past sins in this respect have been chiefly in the standpoint of the critic.

What ought this to be? The prime consideration in the criticism should be the assumption that the investigator whose work is disapproved is neither an ignoramus nor an imbecile. Of course either of these states may be proven, but the evidence must be very decisive if others are to believe. Is such an assumption ever possible? Those who attended the Toronto meeting of the British Association had the opportunity of hearing one distinguished mycologist make a charge

against another which could scarcely proceed from any other assumption, so childish was the blunder imputed to him. At the meeting of the American Association also a paper was read by a young man who had studied the carnation disease for one year charging two botanists who had studied this disease for nearly seven years with most egregious error regarding its cause. Other more remote examples will occur to those who are familiar with botanical history. It may be that Magnus was right and Eriksson was wrong; that Woods was right and Arthur and Bolley wrong; we cannot judge; but we wonder at the attitude of mind which assumes so great possibilities of aberration on the part of another, and so few on one's own. Is it not this sort of criticism, which, couched in irreproachable language, proclaims in effect "See what a silly blunder this man has made, and how easily I expose it," the sort that rankles and leads to estrangement? And having done its evil work in one direction, is it not quite likely to return as a boomerang and smite its author, if, perchance, renewed investigation shows him mistaken?

IF WE ARE to avoid quarrels which quickly run through Touchstone's seven causes, we do well to take heed that our attitude does not imply the quip quarrelsome while our words contain only the retort courteous.

CURRENT LITERATURE.

BOOK REVIEWS.

Pennsylvania forestry.[1]

In these two volumes Dr. Rothrock, the efficient forestry commissioner of Pennsylvania, has embodied what may be considered almost a model method of popular education on a little known subject. Notwithstanding the immense amount of money realized from lumbering in Pennsylvania, and despite the fact that the visible supply of raw material is but a moiety of what was considered an inexhaustible forest less than fifty years ago, the popular apathy regarding forest resources is almost as great in Pennsylvania as in the northwestern states. And yet it must be said that, while other states preceded her in formulating forestry legislation, Pennsylvania has approached the subject in a more business-like way, and is already in the front rank in the protection of forest interests.

The report of 1895 embodies the work of a forestry commission appointed by act of legislature approved May 25, 1893. This commission consisted of a botanist (Dr. J. T. Rothrock) and an engineer (Mr. William F. Shunk), the latter confining his work to the watersheds of the state, and the influence of forests on stream-flow. Dr. Rothrock is responsible for much the greater part of the volume, and it would be difficult to have planned a report better calculated to stimulate popular interest in a failing resource, and to arouse public opinion to the necessity of strong legislative measures for its protection.

It is to be regretted that a book so admirable in its plan should be faulty in its statistics, but this may be pardoned in view of the brief time at the disposal of the commission. It appears that 36.29 per cent of the state area is in timber, but no indication is given of the value of this woodland, which embraces both productive forest and what is practically waste land. Forest fires and the relation of forest to water supply are discussed, and an estimate is given by counties of forest area and conditions. Much the greater part of the report is devoted to notes of a non-technical character on the commercial forest species of the state.

The illustrations are especially noteworthy, and with their graphic titles tell in themselves the story of the evil effects of forest fires and the wasteful extravagance of present methods of logging. It should be remembered that

[1] Annual Report of the Division of Forestry, Department of Agriculture, State of Pennsylvania, for 1895, and for 1896. Harrisburg.

Dr. Rothrock has not attempted a technical discussion of the forestry problem; his evident aim is to educate the people to an appreciation of the importance and value of the forests, a purpose the report is well calculated to serve.

The second volume is a modest pamphlet of fifty-five pages, but to the teacher of forest botany, and the student of legislation for forest protection, it is the more notable utterance of the two. In addition to a preliminary report as forestry commissioner, there is a popular essay on the relation of forests to the farmer and an excellent article on the removal of the fertile soil from the farm by water, both of which contain interesting material for teachers. A black walnut freak, producing fruit, the epicarp of which resembles that of the hickory nut, is described and figured, as is also a weed (*Echium vulgare*) new to the state.

In his report Dr. Rothrock discusses a practical method of securing reliable data of the various classes of timber land in the state — information not heretofore available — taxes on forest land, forest reservations, forest fire legislation, and forests and floods. The report, though brief, is by far the best presentation of forestry needs that has yet appeared, and should have wide publicity.— CHARLES A. KEFFER.

The physiology of plants.

IT HAS BEEN known for some time that Professor Dr. Pfeffer had in preparation a new edition of his treatise on plant physiology. The first volume of this second completely rewritten edition has recently appeared.[2] How completely it has been rewritten appears at once when the 383 pages of the first volume of the first edition are set over against the 620 pages of the same part of the second edition. Since the first edition has occupied so important a position in the literature of plant physiology, it is to be expected that this much more extended one will rightfully maintain the place its predecessor won.

The volume before us is devoted to the discussion of the movements and transformations of matter (*Stoffwechsel*); the second, which is in preparation, is to discuss the transformations of energy (*Kraftwechsel*). After a few introductory chapters, the following are the main headings: Die Mechanik des Stoffaustausches; die Mechanik des Gasaustausches; die Wasserbewegung in der Pflanze; die Nährstoffe der Pflanze; Bau und Betriebsstoffwechsel; Athmung und Gährung; Stoffwanderung. Although so greatly extended, it will be observed that the same general mode of treatment has been retained. While details have been much altered, the fundamental outlines remain the same.

What one feels most strongly in going through the book is that the author

[2] PFEFFER, W., Pflanzenphysiologie, ein Handbuch der Lehre vom Stoffwechsel und Kraftwechsel in der Pflanze. Zweite völlig umgearbeitete Auflage. Erster Band: Stoffwechsel. 8vo., pp. x + 620, figs. 70. Leipzig: Wilhelm Engelmann. 1897. *M* 20. (Bound, *M* 23).

has touched almost every section through his own investigations or those of his students and assistants. This personal contact gives him opportunity for many suggestive hints as to the limitations of our knowledge that will doubtless prove very stimulating and fertile of further investigations. Naturally one turns first to those topics which the author has himself illuminated, but does not find these greatly overbalancing others of like importance. Certainly the most important literature has been well digested, and though, as the author himself fears, there may be oversights in spite of the best intention, these are not striking nor will they be apparent except to the investigator of special problems. Abundant footnote references lead to the original sources.

One of the most noticeable advances is the recognition of the necessity of a name for the formation of carbohydrates; accordingly we find as a subhead *Photosynthetische Assimilation* contrasted with the rare *Chemosynthetische Assimilation*. Nothing can be said in approval of this phrase, which embodies all the old misusage, except that it seems to be a step toward the abandonment of a misuse of the term assimilation. The section on the manufacture of nitrogenous foods is also greatly improved and extended, now including a discussion of the fixation of free nitrogen by Leguminosae.

Excellent and useful as the work is, it must be said that there are several things which detract seriously from its value. Perhaps they need to be specified all the more since they were equally marked in the first edition and ought to have been corrected in this. Though the book is not intended for beginners, we cannot think that the presentation of the subject is a matter of indifference. Pfeffer's presentation is radically bad. In the first place, his style is so peculiar and involved that it is repellent to the highest degree, and English students who read German with ease will be constantly irritated by the recurrence of uncouth and un-Germanic words and phrases. In the second place, there is a total lack of logical precision of statement, accompanied by much repetition and verbosity. These two faults are aggravated by the want of suitable paragraphing, with titles, so that in parts page after page runs without a break to indicate where a given topic may be found. And when, after search, it is found, the chances are that it is only partially discussed, while the author recurs to it in another place.

Is it to become necessary for scientific men to return to the practice of ages agone, and call in the rhetorician when writing is to be done? Certainly the ancients had the advantage of some of us moderns in recognizing the fact that they needed professional aid in presenting their ideas. Not a few recent books would have been the better for thorough editing by an adept in the art of expression. With a masterly grasp of the subject, it was the graphic and artistic presentation which won for Sach's *Vorlesungen über Pflanzenphysiologie* an almost unique place in botanical literature. Pfeffer shows extraordinary knowledge of the subject and remarkable fertility in suggestion, but lacks sadly the art of logical and picturesque presentation.

Spite of these defects, which we hope will not prevent translation of this edition (as they did of the first), physiology will be greatly advanced by this valuable work. We shall await the second volume with even greater interest, hoping that it may be completely remodeled, for *Kraftwechsel* needs today a radically different approach and treatment from that which it received in 1881.—C. R. B.

MINOR NOTICES.

BLACK ROT of the cabbage, by Erwin F. Smith, forms Farmers' Bulletin no. 68, recently sent out by the U. S. Department of Agriculture. It is a more popular account of the same study to which attention was called in the January GAZETTE, with additional field observations and rules for prevention. —J. C. A.

THE DIVISION OF BOTANY of the United States Department of Agriculture has issued a bulletin describing the camphor tree, its uses, conditions of successful cultivation, a map showing the area of the United States wherein it might be grown, together with some information as to the commercial outlook for camphor.—C. R. B.

PROFESSOR M. A. BRANNON, of the State University, has published a report on the grasses and forage plants of North Dakota. The field work was begun under a commission from the Division of Agrostology of the U. S. Department of Agriculture. The report contains valuable notes concerning distribution, nature of soil, etc.—J. M. C.

THE MOVEMENTS of plants was the subject of a lecture by Professor D. T. MacDougal, of the University of Minnesota, before the Institute of Jamaica, given in June last, while on a visit to the island in the interests of the proposed tropical laboratory. It is printed in the *Bulletin of the Bot. Department, Jamaica*, for Oct.-Nov., and has been distributed separately. It gives a general review of the subject, with illustrations drawn from the common plants of the island.—J. C. A.

MR. N. A. COBB, of the Department of Agriculture, New South Wales, sends us his "Letters on the diseases of plants," a pamphlet of 54 pages issued by the Department at Sydney. It is a compilation of letters written in answer to correspondents who have requested information from the department regarding various plant diseases. The information is put in a popular yet accurate way, and the illustrations, to the number of one hundred, are excellent. The writer shows himself well in touch with the extensive work of this kind carried on in the United States.—C. R. B.

THE SEVENTH CONTRIBUTION from the Botanical Department of the Agricultural College of Iowa is devoted to a list of plants collected in the

District of Cienfuegos, Province of Santa Clara, Cuba, in 1895–6, by Robert Combs. The flora of Cuba in general is discussed, the statement being made that it is "interesting, not only for its great number of endemic types, but also for the striking characters of those types, their occurrence, distribution, and economic uses." The flora very closely resembles that of Central and South America, and is said to differ more from that of adjacent Florida, than does the latter from the flora of Canada. The catalogue is a very full one, and is accompanied by ten well-prepared plates.—J. M. C.

THE NEW *Journal of Applied Microscopy*, announced by the Bausch and Lomb Optical Company, has made its appearance. It is devoted to microscopical instruments and technique viewed from a practical standpoint. If the standard set by the first number is maintained the new journal will prove very useful to teachers of botany and zoology, and microscopists in general. Besides many suggestions regarding the use of lenses and other apparatus, this number contains valuable directions for the study of the myxamœbæ and plasmodia of the Mycetozoa. Methods of more direct interest to zoologists are also contained in this initial number.—C. J. C.

THE MOST RECENT *Bulletin*[3] from the Iowa State University contains an account of the ferns collected by B. Shimek on the Nicaragua botanical expedition of the University in 1893. The report is exceedingly well done, the greatest care apparently having been taken in the determinations and in the organization of all available data. The author has done well to append to each genus a list of all species reported from Nicaragua not included in his collection. Twenty remarkably good plates accompany the contribution. The total number of species and varieties reported from Nicaragua is 198, representing 39 genera, of which 126 species and 32 genera were collected by Mr. Shimek. The report adds one new species, seven new to Central America, and thirty-seven new to Nicaragua. It seems that of the species collected by Mr. Shimek eighty-one are terrestrial, forty-one are epiphytic, and two have adopted both habits.—J. M. C.

THE REVISION of the genera of Hepaticæ is progressing in the hands of various American students with considerable rapidity. In addition to the general treatment of the whole group by Dr. Underwood in the Systematic Botany of North America, which may be expected shortly, Mr. Alex. W. Evans has recently given us a full account of the North American species of Frullania, accompanied by fifteen plates.[4] With the exception of Jungermania, Frullania is the richest in species of all our hepatic genera. Dr. Evans

[3] Bull. from Lab. Nat. Hist. **4**: 95–224. 1897.

[4] EVANS, ALEXANDER W.—A revision of the North American species of Frullania, a genus of Hepaticæ. Transactions of the Connecticut Academy of Sciences **10**: 1–39. *pl. 15*. May 1897.

recognizes twenty-two species, of which two are imperfectly known. The drawings, illustrating the species, made by the author, are admirable in their clearness and fullness. The following changes from the names in Gray's Manual are noted: *F. Pennsylvanica* has already been transferred to Jubula; *F. saxicola* is referred to *F. Virginica*, and *F. fragilifolia* Aust. (not Tayl.) to *F. Selwyniana* Pearson; *F. æolotis* is *F. riparia* Hampe; and *F. dilatata* is described as *F. Brittoniæ*, n. sp.

Mr. Marshall A. Howe has lately examined the species of Porella[5] belonging to North America. Schiffner in Engler and Prantl's *Pflanzenfamilien* rejected the name Madotheca, which Dumortier adopted for this genus, and also considered Porella a *nomen nudum* of Linnæus. But Howe, backed by the recent examination by Underwood of the Dillenian plant at Oxford, follows Lindberg and others in the use of Porella. He recognizes eight species. The five of Gray's Manual are pretty well changed. *P. Sullivantii* is referred to *P. pinnata; P. Thuja* to *P. platyphylla;* while *P. dentata* becomes *P. rivularis* (Nees) Trevis.—C. R. B.

AFTER LONG interruption the *Contributions* fron the Botanical Laboratory of the University of Pennsylvania have been resumed by the publication of no. 3 of vol. I. It contains three papers: A chemico-physiological study of *Spirogyra nitida*, by Mary E. Pennington, Ph.D.; On the structure and pollination of the flowers of *Eupatorium ageratoides* and *E. cœlestinum*, by Laura B. Cross, Ph.D.; and Contributions to the life-history of *Amphicarpæa monoica*, by Adeline F. Schively, Ph.D. The first of these papers is particularly meritorious. Not only does it bring out some interesting new facts which are connected with those already known, but it shows ingenuity in the devising and execution of the experiments. Particularly useful to other workers will be the carefully described set of color screens, by means of which monochromatic light may be secured. They seem a decided improvement on other formulæ. Perhaps the most interesting conclusion is that the influence of monochromatic light on the growth of Spirogyra is due mainly to the effect of the particular light on diastase.

The second paper is very brief. By her experiments the author is led to the conclusion that self-pollination in the two species of Eupatorium is very rare indeed, and that even when it does occur the fruits are of weak germinating capacity. The visits of insects, however, insure a large percentage of good fruits.

The third paper is a very detailed account of the morphology and physiology of Amphicarpæa; a useful catalogue of facts, but not correlated with others by the author. One fact of interest is that this plant has very rapid circumnutation movements, completing a circuit in 51 minutes.—C. R. B.

[5] HOWE, MARSHALL A.—The North American species of Porella. Bulletin of the Torrey Botanical Club **24**: 512–527. N 1897.

NOTES FOR STUDENTS.

In a paper by C. Warnstorf, entitled "Beiträge zur Kenntniss exotischer Sphagna,"[6] in the midst of a large number of new species from Brazil, Australasia, South Africa and Reunion, two new Sphagna subsecunda from the United States are described, and several new stations given for species already known. One of the new ones is *S. Langloisi*, from St. Martinsville Louisiana, and the other *S. xerophilum*, from Alabama.—C. R. B.

Mr. Charles H. Peck's annual report for the year 1895, as state botanist of New York, was recently issued. Beside the bare list of additions to the herbarium and names of contributors, it contains observations upon fifty species of plants not before reported for the state of New York, of which seventeen species, all fungi, are described as new to science. There are also remarks on thirty-one other species, over half being flowering plants; seven species of the fungi have new varieties described. The New York species of the genus Collybia, numbering thirty-four, are monographed, with revised descriptions, extended notes and carefully prepared keys, together with a key to the twenty extra-limital species. Ten species of edible fungi, and one unwholesome species, are described and illustrated with colored quarto plates, forming a supplement to the notable issue of the previous year, The quarto form fits in badly with the octavo form previously adopted, but as the plates only are in quarto, they can be once folded when bound, and by this simple means the whole series kept uniformly in octavo.—J. C. A.

Items of taxonomic interest are as follows: John K. Small[7] has described some additional new species (Vicia, Samolus, Limonium, Eupatorium, Chrysopsis, Silphium) from the South Atlantic states. Edward L. Greene[8] has described some new Compositæ (Coleocanthus, Erigeron, Machæranthera, Gaillardia) from New Mexico and Arizona. Eugene P. Bicknell has described a new species of Asarum[9] heretofore confounded with *A. Canadense*, and two new species of Sanicula.[10] Mrs. E. G. Britton[11] has published a revision of the North American species of Ophioglossum, recognizing eight species, two of which are new. *O. vulgatum* of the southwest is *O. Engelmanni* Prantl. T. H. Kearney[12] has published a very interesting series of plants from eastern Tennessee, several of which are new (Cimicifuga, Stylosanthes, Scutellaria, Xanthium). Miss Alice Eastwood[13] has begun a series of papers entitled "Studies in the herbarium and the field," the first number containing new forms of Œnothera and Bigelovia, two new spurless forms of

[6] Hedgwigia, **36**: 145–176. 1897.
[7] Bull. Torr. Bot. Club **24**: 490–493. 1897.
[8] *Ibid.* 511–512.
[9] *Ibid.* 528–536.
[10] *Ibid.* 577–582.
[11] *Ibid.* 545–559.
[12] *Ibid.* 560–575.
[13] Proc. Cal. Acad. Sci. III. **1**: 71–88. 1897.

Aquilegia, new species of Iris, Montia, and Newberrya, and three new species of Arctostaphylos. The Royal Botanic Gardens of Trinidad has begun the publication[14] of descriptions of the ferns of the British West Indies and Guiana, by G. S. Jenman, government botanist of the Colony of British Guiana. The first fascicle contains Hymenophyllum and Trichomanes, the former represented by twenty-nine species (two of which are new), the latter by forty-two species (one of which is new). Mrs. Katherine Brandegee[15] has begun a valuable series of papers entitled "Notes on Cacteæ." The first number discusses the forms of Lower California, concerning which the author is specially competent to speak. The race for new African species is becoming more interesting daily, and most of the taxonomic centers of Europe are competitors. Wood and Evans[16] have published a second decade of "New Natal plants;" the work directed by Engler has resulted in a fascicle of ten papers in the most recent number of the *Jahrbücher*,[17] the families presented being Sapindaceæ (Gilg), Acanthaceæ (Lindau), Gramineæ, Cyperaceæ and Commelinaceæ (Schumann), Compositæ (Hoffmann); while Durand and Wildeman[18] have published the first fascicle of a list of Congo plants, among which many new species are described. Hallier[19] has begun the publication of a revision of Convolvulaceæ, the first paper containing Calonyction, all of whose six species belong to the American flora, having been referred usually to Ipomœa and Convolvulus. Huth[20] has published a descriptive list of Japanese Ranunculaceæ, in which seventeen genera are represented, all of which have representives in America. Eighty-three species are enumerated, the largest genera being Ranunculus (13 species), Clematis (12), Thalictrum (12), Anemone (11), Coptis (6), and Trollius (6). Glatfelter[21] has discussed *Salix longipes* and its relation to *S. nigra*.—J. M. C.

THE SUBJECT of contractile roots is assuming larger and more definite proportions. A. Rimpach[22] has summarized the subject, finding that seventy species, representing twenty families of monocotyls and dicotyls, are recorded as possessing contractile roots. The power has been observed only in herbaceous, and chiefly in geophilous plants. The greatest amount of contraction is said to be 70 per cent., and the families most frequently represented are the Liliaceæ, Iridaceæ, Amaryllidaceæ, and Araceæ.—J. M. C.

[14] Bull. Misc. Information **4**: 1–32. 1898.
[15] Erythea **5**: 111–123. 1897.
[16] Jour. Bot. **35**: 487–490. 1897.
[17] Bot. Jahrb. **24**: 305–464. 1897.
[18] Bull. Soc. Roy. Bot. Belgique **36**: 47–97. 1897.
[19] Bull. de l'Herb. Boiss. **5**: 1021–1052. 1897. [20] Loc. cit. 1053–1096.
[21] Rep. Mo. Bot. Gard. **9**: 1–9. 1897.
[22] Beitr. z. wiss. Bot. (Fünfstück) **2**: 1–28. 1897. Cf. Jour. Roy. Micr. Soc. Dec. 1897, p. 551.

THE EMBRYOGENY of Triticum has been investigated by M. Koernicke.[23] He finds the usual axial row of four mother cells in the ovule, the lowest of which develops the macrospore. As already well known among Gramineæ, the antipodals are most apt to develop a more or less extensive tissue, which the author considers to be accomplished by direct division. The chromosomes were found to be usually sixteen in number in the vegetative cells of the inflorescence, eight in the mother cells of both microspores and macrospores, and sixteen again in the oospore.—J. M. C.

DAVID M. MOTTIER has recently published a paper[24] on the behavior of the nuclei in the development of the embryo sac and the phenomena of fertilization. The plants studied were *Lilium Martagon*, *L. candidum*, *L. umbellatum*, *Helleborus foetidus*, and *Podophyllum peltatum*, the same plants as those used by the author in his previous paper[25] upon a related subject. The methods were also the same.

At an early stage in the development of the primary nucleus of the embryo sac a remarkable differentiation takes place in the cytoplasm. Numerous kinoplasmic threads appear which may form a felt around the nucleus, or may take the form of strands radiating from the nucleus, or may even be separated from the nucleus and form a bunch in one end of the cell. Later these threads disappear, and the cytoplasm seems to have a uniform structure. The spirem and segmentation stages take place just as in the author's description of pollen mother cells. He still regards synapsis as an artefact.

He refers to the only previous description of spindle formation in plants, that of Guignard,[26] who says the spindle takes its origin from two directive spheres. Since Mottier declares that there are no directive spheres in pollen mother cells or embryo sacs he necessarily looks for some other method of spindle formation. He finds kinoplasmic fibers variously arranged which press into the nuclear cavity as the nuclear membrane disappears. Some of these fibers become fastened to the chromosomes and soon form a multipolar spindle which quickly becomes bipolar. The chromosomes are V-shaped, with the point toward the pole. The first division in the embryo sac is heterotypic, and agrees fully with that already described in pollen mother cells.

The second division follows without a complete resting stage. The spindle formation is the same as in the first division, but not so easily studied. Mottier was surprised to find that the segmentation of the spirem came after

[23] Verhandl. Naturhist. Ver. Preussen Rheinl. **53**: 149–185. 1896. Cf. Jour. Roy. Micr. Soc. Dec. 1897, p. 553.

[24] Ueber das Verhalten der Kerne bei der Entwickelung des Embryosacks und die Vorgänge bei der Befruchtung. Jahrb. wiss. bot. **31**: 125–158. 1897.

[25] Beiträge zur Kenntniss der Kerntheilung in den Pollenmutterzellen einiger Dikotylen und Monokotylen. *Ibid.* **30**: 169–204. 1896.

[26] Ann. Sci. Nat. Bot. VII. **14**: 163–296. 1891.

the spindle was fully formed. The same phenomenon was described by Professor Coulter[27] after Mottier's article was written, but before it had reached the Chicago laboratory.

The third division is like the second rather than the first. The lower antipodal spindle is often abnormal, but the division is not considered amitotic as described by Miss Sargant. The polar nuclei, unlike the synergids and the egg, are not surrounded by a "Hautschicht," that of the egg apparatus being formed from the connecting fibers. At the time of fusion both the sex nuclei are in the resting stage. The membrane between the nuclei disappears, and after the fusion it is impossible to distinguish the male and female portion of the new nucleus.

After describing nuclear division in vegetative cells, the vegetative division is compared with the heterotypic, the structure of the resting nucleus being the same in both. In both there is a longitudinal fission of the nuclear thread. In the heterotypic there is often a synapsis due to reagents. The chromosome segments form rings or ellipses, or lie over each other before they are arranged in the nuclear plate; and in separating, the V-shaped chromosomes have the spindle fibers attached at the apex, while in the vegetative form the spindle fibers are attached at or near the end of the chromosome.

Mottier finds that while a reduction in the number of chromosomes takes place in the primary embryo sac nucleus, there is no so-called reduction division. This does not agree with his work on pollen mother cells, and he will consequently reinvestigate that subject.—C. J. C.

[27] BOT. GAZ. **23**: 416. *pl. 32, figs. 10, 12.* 1897.

NEWS.

GEBRÜDER BORNTRAEGER have issued a neat pamphlet containing a full description of their numerous scientific publications.

PROFESSOR DR. GREGOR KRAUS has been called to the professorship of botany in the University of Würzburg, as successor to the late Julius von Sachs.

THE AMERICAN BOOK COMPANY announces the early appearance of "A laboratory manual in practical botany," by Charles H. Clark, Principal of Windsor Hall, Waban, Mass.

ARRANGEMENTS have been made for an English translation of Pfeffer's "Physiology," by Dr. Ewart, to be published by the Clarendon Press. A French translation is also to be published in Paris.

MR. JOHN W. HARSHBERGER has published an ecological sketch of the vegetation of the Yellowstone hot springs in the *American Journal of Pharmacy* for December 1897.

THE ISSUE of *Photogravures of American Fungi*, by C. G. Lloyd, has reached number 22. The last two numbers show fine reproductions of *Lepiota Americana* Pk., and *Calvatia cælata* Bull.

DR. GYULA ISTVANFFI, chief of the botanical section of the Hungarian National Museum at Budapest, and privat-docent in the University, has been called to the professorship of botany in the University of Klausenburg.

A BIOGRAPHICAL SKETCH of the late Dr. J. E. Humphrey is published in *Johns Hopkins University Circular* **17**: no. 132, Nov. 1897, prepared by J. S. Kingsley and B. W. Barton. A bibliography is appended, containing thirty titles, extending from 1886 to 1896.

F. KEMPE, a wholesale merchant of Stockholm, has established a fund of 150,000 kroner (about $40,000) for the foundation of a professorship and an institute of plant ecology in the University of Upsala. Dr. A. N. Lundström, docent, has been called to the chair.

WE OMITTED to make announcement, at the proper time, of the death of Henry N. Bolander, whose collections on the Pacific coast have done so much to make known the flora of that region. He had been a resident of Portland, Oregon, for some years, where he died August 28, 1897.

DR. DOMENICO SACCARDO, of the Royal Botanical Garden at Padua, has just issued the first two centuries of a *Mycotheca Italica, seu Fungi Italici exsiccati*, which is said to contain some new species and many forms not hitherto published in exsiccati. The price is *fr.* 15 per century.

THERE HAS JUST COME to us a paper by Professor Thomas C. Porter on "The Pennsylvania-German in the field of the natural sciences." It contains most interesting accounts of several botanical worthies, together with their portraits. Among these we note Mühlenberg, Schweinitz, Wolle, and Garber.

AT THE thirteenth annual meeting of the Indiana Academy of Science, held at Indianapolis December 29 and 30, 1897, fifteen botanical papers were presented out of a total of eighty. The following officers were elected for 1898: *President*, C. A. Waldo, Purdue University; *Vice-President*, C. H. Eigenmann, Indiana University; *Secretary*, John S. Wright, Indianapolis. The volume of proceedings is a public document, a limited number being printed by the state, the copies being distributed by the state librarian under the direction of the Academy.

AN EXPEDITION for the collection of all classes of flowering and cryptogamous plants is being arranged, for the season of 1898, to explore the La Plata and San Juan mountains of southeastern Colorado. Specimens will be secured to illustrate, so far as possible, not only the species of the region, but also the range of variation due to environment, such as climate, altitude, and exposure. Sets of specimens will be sold at $7 per hundred, of either the complete series, or particular groups, as preferred. Prospective purchasers can obtain information of Mr. Carl F. Baker, Auburn, Alabama.

WITH THE NEW YEAR the *Pharmaceutical Review* changes its form from quarto to large octavo. It also announces that more space will be devoted to the monthly review of pharmaceutical literature. To accommodate the large amount of original matter which has increasingly crowded out these reviews a new journal, *Pharmaceutical Archives*, will be established under the editorship of Dr. Edward Kremers, of the University of Wisconsin. The new form of the *Review* is certainly more convenient than the old one, with its double-columned pages, which necessitated the annoying repagination of all articles reprinted. We congratulate the editors on the improvement.

A BOTANICAL CLUB was organized in St. Louis last December, to be known as the "Engelmann Botanical Club." It is planned to have regular bimonthly meetings for the reading of papers and reviews, and to have field days in the spring. The following officers were elected for 1898: *President*, William Trelease; *Vice-Presidents*, G. W. Lettermann and Henry Eggert; *Secretary*, Hermann von Schrenk. At the meeting of January 13, L. H. Pammel read a paper on the flora of Iowa; J. B. S. Norton discussed the

coloring matter of some North American Boraginaceæ, and H. von Schrenk spoke of *Merulius lacrymans* and its occurrence in the cypress marshes of northern Mississippi.

IN THE REPORT of the botanist of the Department of Agriculture for 1897, the work of the year is considered under the following heads: field experiments with seeds, investigation of new crops, national herbarium, economic herbarium, natural resources, weeds, poisonous plants, testing seeds distributed by the department, seed investigation, support of the pure seed movement, American medicinal flora. This gives some idea concerning the subjects which have been interesting the division. The needs for the ensuing year are said to be a building, permanent trial grounds, and an additional assistant to investigate the subject of "natural agricultural belts or areas as indicated by the natural vegetation."

ONE of the most vigorous of American scientific societies is the American Society of Naturalists. Founded in 1883, meeting annually between Christmas and New Years in some one of the eastern cities, and aiming to promote those interests which naturalists have in common, it has not only grown itself, but it has attracted to meet with it several other leading scientific societies. The annual meetings of these affiliated societies have become of rapidly increasing importance, until at present they are second to none in this country in influence and value. For two or three years past associations of animal morphologists, animal physiologists, animal anatomists, psychologists, and finally anthropologists have met to hold, along with sessions of their own, others in common with co-workers in related fields. In this development botanists have taken no part. A few have been accustomed to attend the meetings of the central society, the Naturalists, but as the special societies have gradually attracted the more special biological subjects into themselves, these meetings have become of less use to them. At the same time many botanists have felt that a most valuable opportunity is being wasted by their failure to meet along with these vigorous organizations, and, moreover, that the science and profession both suffer by their silence when the related sciences are being brought so conspicuously and favorably into notice. This feeling expressed itself at the Philadelphia meeting in 1895 in a meeting of the botanists present, and the appointment of a committee, with the late Dr. J. E. Humphrey as chairman, to investigate the question of the desirability of forming a botanical organization to meet annually with the other scientific societies. By correspondence during the ensuing year the committee became convinced that there was no call for a new botanical society of general scope, and it became a question of a society of special character and limited range of membership, or none. This report was made to a meeting of botanists present at the Boston meeting of the affiliated societies December 30, 1896, and those present, after full discussion, constituted themselves a "Committee

on the organization of a society for vegetable morphology and physiology, to meet annually with the American Society of Naturalists." Those present were Messrs. W. G. Farlow, W. P. Wilson, J. M. Macfarlane, Miss Emily Gregory, B. L. Robinson, R. Thaxter, H. M. Richards, J. M. Greenman, W. F. Ganong. W. F. Ganong was appointed secretary. During the year eleven other botanists were invited to join the committee, and accepted. They were Messrs. G. L. Goodale, Miss Clara E. Cummings, D. P. Penhallow, G. E. Stone, W. C. Sturgis, J. E. Humphrey, B. T. Galloway, E. F. Smith, L. H. Bailey, G. F. Atkinson, E. A. Burt. During the year a scientific meeting was arranged for, which was held along with the affiliated societies at Ithaca, December 28, 1897, and which is fully reported in this number of the GAZETTE. At a business session on December 27th, the Committee organized itself into a "Society for the promotion of research in plant morphology and physiology, with the general understanding that it shall meet with the American Society of Naturalists," and adopted as a name, "Society for plant morphology and physiology." Rules for the government of the society were drawn up and the following new members were elected: V. M. Spalding, H. J. Webber, W. T. Swingle, W. W. Rowlee, J. W. Harshberger, D. G. Fairchild, R. A. Harper, A. F. Woods, A. J. Pieters, G. H. Hicks, H. C. Porter, Miss Harriet L. Merrow, Theo. Holm. Officers for the ensuing year were elected as follows: *President*, W. G. Farlow; *Vice-Presidents*, J. M. Macfarlane, G. F. Atkinson; *Secretary-Treasurer*, W. F. Ganong. Membership is of course not limited geographically, but it is expected mainly to be drawn from those who live near enough to the places of meeting of the Society of Naturalists to enable them to attend regularly.

This description of its origin will show that the new society is not in the least intended to interfere in any way with the work of the older societies, but it is meant to fill a place which they do not occupy. It seems plain to its founders that botanical activity in this country has become great enough to need all of these societies for its expression, and specialized enough to need special societies devoted to particular branches of it, a condition which was realized some time ago in the sister science of zoology.—W. F. GANONG.